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The purpose of this American Orthopaedic Association should be to develop our branch of surgery into an exact science. It is my feeling that in the past we have hampered ourselves in several ways in this development. We must correct our errors and stand in the future for the highest principles and the truth in this special branch of surgery.

It is not possible to free ourselves at once from all the dogmas which have been handed down to us by past generations, but as soon as a supposed fact has been disproved it should be abandoned. We must free ourselves from the occult, the mysterious, and the wonderful, and give up all terms and expressions which are not based on carefully observed and recorded facts.

As we are an Association, there should be no hesitancy in reporting our results to one another, and this should be done on a much larger scale and in a more systematic way than in the past. The cases should be uniformly recorded and compiled for study. The various commissions appointed for the study of end results have accomplished much, but even more truths may be discovered by an expansion of this method in the future. For example, Dr. Smith-Petersen of Boston has just developed a method for fastening the broken neck of a femur by a specially constructed nickel nail which holds the broken ends of bone in exact approximation with great firmness. This diminishes the time of incapacity by many months. The operation requires special instruments and careful technique, but can be accomplished under proper conditions by any well trained orthopaedic surgeon with good assistants. Let every operator who thinks well enough of the procedure to practise it, report in detail the conditions and the end results in his cases to some specially appointed commission for their study.

*Read at the meeting of the American Orthopaedic Association, Chatham, Mass., June 21, 1930.

The same methods of study should be carried out with Dr. Albee's operation for dowelling the neck of the femur. Dr. Albee has demonstrated that he can successfully accomplish the procedure, but he has contributed but little to the advancement of our science unless others can do this operation with success. Let every member who has performed the operation, successfully or otherwise, report his cases in detail to Dr. Albee or to a specially appointed commission, in order that we may learn. In Gallie's operation for slipping patella, LeMesurier's operation for recurrent dislocation of the shoulder, Orr's operation for osteomyelitis, Campbell's operation for drop-foot, Silver's operation for hallux valgus, and many other procedures, the end results should be similarly compiled and studied. If such a system of recording, reporting, and compiling all our cases with their end results could be established in this Association, it would have far-reaching effects of great benefit to all.

Unless supported by facts, talk and supposition are nothing in the advancement of a great science like Orthopaedic Surgery. What we must seek and record are the carefully compiled facts. Problems are constantly arising which demand solution; conclusions must not be jumped at even by the brightest mentalities, but the comparative reports of large numbers of cases in the hands of many different operators will come near the truth.

In spite of the glowing accounts of cures of tuberculous bone disease by sunlight, there are many of experience who realize that the cures are not as rapid, complete, and permanent as we could hope. And again this Association should so organize itself that a study of the facts, conditions, and end results of these tuberculous bone and joint cases studied over a long period, may be tabulated. In my experience, many months, even years, of heliotherapy convert the active process into a low-grade smouldering type (the caries sicca) which may at a later period become active. This is particularly true in the adult cases. But such a statement can be proved only by a long careful observation of our cases and the recording of such observations in large numbers by many different observers. What organization could better perform such a work than this Association? Should not this be one of our functions, perhaps in the future our chief function?

The recent experimental studies of arthritis have contributed some real facts which help in the understanding of this very difficult problem. We know that unless by a punctured wound or direct extension, nothing can reach our joints except through the blood stream. We realize that gonorrhoeal organisms, streptococci, tuberculous bacilli, and many other microorganisms are recovered from the diseased joints. These infected joints then should form one group in, or classification of, arthritis.

It has been supposed that infectious processes back of the tonsils, around the tooth roots, or occurring in other places where there is no satisfactory external drainage, may produce toxins,—harmful chemical substances which irritate and destroy the joints. These toxic types of joints may form another group in the classification. But as the art of culturing bacteria outside the body is developed, types from this group are constantly

being transferred to the infectious group. Does toxic arthritis exist, or is this group simply surmise? Let the laboratory man continue his search.

The other hypothetical group of joint disturbances is that due to chemical changes in the internal processes during the digestion of food. Instead of producing the chemical substances which build up, nourish, and repair the joints, the digestive process produces a chemical substance which destroys the joints.

Infectious, toxic, and metabolic,—these, then, are the three classes into which arthritis has been grouped, and should be the basis of our nomenclature.

I feel that such terms as atrophic arthritis, rheumatoid arthritis, and Still's disease should no longer be employed. They give no comprehensive idea of the disease, and lead to confusion. Osteo-arthritis and hypertrophic arthritis,—these terms tell you nothing of the cause of the disease, and are only an imperfect description of the pathologic process; and unfortunately they give the impression that we know something about the condition which we do not know; and this is a most important thing which the orthopaedic surgeon of the future must avoid and from which he must free this specialty.

The mysterious and the wonderful still attract the public. There are still registered practitioners of medicine who will not accept the facts,—for example, those who still contest the virtue of vaccination against smallpox.

Let this Association stand for clarity in our knowledge and in the terms with which we express ourselves. Let us choose the terms which are most exact and descriptive, and not confuse people and ourselves by a multiplicity or duplicity in terms.

In this same line of thought there are several affections which serve as illustrations.

In healthy children a real back strain is a very rare occurrence; in the perfectly healthy young adult it is also rare. Although the healthy young spines at times are subjected to great violence in lifting, wrestling, football, and hockey, they rapidly recover from the traumata. The so called back strains frequent in middle life mean to my mind that some pathologic change has taken place either in the joints or in the ligaments or in the muscular attachment, as Albee believes. Suffice it to say that these sacro-iliac and so called back strains have as their cause something very much more important, so far as we are concerned, than a strain. It is of primary importance that we should determine just what is the cause,—whether an arthritis or something else. The trauma may be slight but the pain and incapacity prolonged, and the industrial loss very great. The general public as well as the general practitioner look to us for the true answer to this question. Can we give it with truth and certainty? Let us band ourselves together to systematically examine, record, and study a very large number of these cases and find the truth.

In order to study our cases intelligently, our classification and nomenclature should be revised. A club-foot is a club-foot, but there are those that are acquired through infantile or other paralyses, and those that are congenital; still, the congenital equinovarus club-feet are not all alike, and the accompanying congenital defects should always be recorded, for they affect the prognosis and the treatment.

Scoliosis, in the past described, and in some textbooks still dealt with as an entity, is but a condition arising from one of several causes, and in dealing with a case our description should include some statement of the cause or probable cause, for the different types certainly require different methods of treatment.

When considering congenital dislocation of the hip, the age of the child and the fact of a previous attempt at reduction should always be included in the description of the case. In a large proportion of the hips reduced, either by the closed or open method, before the child is two years old, a more or less functionally perfect and often anatomically perfect hip will be obtained. After the age of two years, such profound changes may take place in both the head and the socket that sometimes the hips cannot be reduced at all, or if reduced they will never be normal, or will be so deformed that they will not stay reduced. I much wish that the Committee for the Study of Congenital Dislocation of the Hip could be perpetuated, so that every case treated by any member of this Association would be systematically recorded and tabulated for study and comparison. Fortunately we have not as many cases in this country as they have in Italy and Southern France, but there are a sufficient number in America if we all will contribute all our cases. Congenital dislocation does not kill a person in middle life, as cancer, but it certainly produces a hopeless crippling, and therefore demands our careful study.

The education of the public, the State census of the crippled, the propaganda of the Shriners, all are helping to bring the cases to the orthopaedic surgeon for treatment. We must abandon old dogmatic theories, and band this Association more closely together into an organization that will report for study all the cases that are treated by us. If we would compile our results and study them, I am certain this Association could contribute much valuable information, which would make the teaching of Orthopaedic Surgery more accurate, our prognoses more certain, and our results more exact, for then our practice would be based upon well thought out, proven facts.

STENOSING TENDOVAGINITIS AT THE RADIAL STYLOID PROCESS

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In 1895 de Quervain described a previously unrecognized condition affecting the tendon sheath of the abductor longus and extensor brevis pollicis tendons, which occupies the first compartment on the dorsal surface of the radius, near the styloid process. This condition was characterized by definite symptoms and physical signs and responded readily to appropriate treatment. Subsequently a number of articles along similar lines appeared in the foreign journals. Strange to say, scant recognition has been accorded this subject in the American literature. The only references to stenosing tendovaginitis in this country are the following: In March, 1927, five cases from the writer's service at the Hospital for Joint Diseases were shown at a meeting of the Orthopaedic Section of the New York Academy of Medicine by Dr. H. C. Stein and reported under the Transactions of the Section in the American Journal of Surgery, July, 1927 (III, 77). More recently an article entitled, "Stenosing Fibrous Tendovaginitis over the Radial Styloid (de Quervain)" by Dr. C. C. Schneider, Milwaukee, Wisconsin, appeared in the June, 1928 (XLVI, 846), issue of Surgery, Gynecology and Obstetrics.

The fact that so few reports on stenosing tendovaginitis appear in the American literature does not mean that the condition is uncommon in our country, for during the period between 1926–1928 twenty-four cases were operated upon for this lesion at our institution*. This condition is apt to be erroneously diagnosed as rheumatism, neuritis, periostitis, tenosynovitis and even tuberculous osteitis.

The pathological changes are not widely understood, the treatment of the condition was often irrational and unsuccessful. Stenosing tendovaginitis, unless properly diagnosed and treated, is progressive and tends towards chronicity. It is not only painful but at times disabling, and because it is generally seen in the working classes it may seriously affect the economic status of the patient. It is hoped, therefore, that a deeper and a more comprehensive knowledge of the various factors which constitute the disease process will facilitate its diagnosis.

REVIEW OF THE LITERATURE

De Quervain in his original contribution reported five cases. All were females; their ages varied between twenty-five and fifty-five. Their

*Eight additional cases have been operated upon since the completion of the above article.

complaints were strikingly similar, consisting of pain at the radial styloid process radiating down the thumb and up the forearm, slight swelling in the region of the tendon sheath, pain on movements of the thumb and wrist, and inability to firmly grasp objects. Conservative treatment,—such as baking, massage, rest and immobilization, failed to relieve the symptoms. Two cases at operation showed fibrous thickening of the tendon sheath fascia, which caused constriction of the enclosed tendons. On incising this tendon sheath there was immediate relief. Welti, in 1896, reported a similar case, due to overexertion of the thumb, which was successfully treated by extirpating the entire tendon sheath fascia. In 1903 Marion, without knowledge of de Quervain's report, cited several cases which he treated conservatively. Poulsen, in 1911, reported two cases and suggested that the lesion might be a periostitis due to traction by the tendon sheath fascia. In 1912 de Quervain reported eight additional cases which were cured by operation. He stated that the most frequent exciting cause was overexertion from household duties; occasionally there was a gouty or rheumatic history. Tuberculosis and syphilis were excluded in the entire group. During the same year Flörcken described two cases, diagnosed at first as tuberculosis of the radius, but in view of negative x-ray findings, he finally decided that he was dealing with de Quervain's disease. Conservative treatment was unsuccessful in both cases. Michaelis attributed the cause to a thickening of the tendon sheath due to chronic inflammation of the ligament, producing a constriction of the tendons. The tendons showed no pathological changes. Burk, also in 1912, ascribed the cause to an habitual subluxation of the carpometacarpal joint. Nussbaum, in 1916, gave a résumé of forty cases previously reported. The histological findings were emphasized and will be referred to later. Keppler, in 1917, reported twenty-five cases seen within a period of eighteen months; seventeen were operated upon, and eleven of these, in which a follow-up examination was obtained, reported no recurrences of the complaint. He also described the histological findings in twelve patients. He concluded that the process was a chronic inflammation caused by protracted or repeated aseptic irritations. In 1919 Vischer added nine cases; and in 1920 Goeldel reported nine cases of styloiditis, stating that it was very easy to mistake epicondylitis of the styloid process of the radius for inflammation of the tendon sheath or stenosing tendovaginitis. In the same year Reschke reported ten cases. He found that in protracted cases the tendons were secondarily affected. He treated acute cases conservatively with many failures. In chronic cases division of the tendon-sheath compartment was the only effective procedure. Troell reported six cases in 1921, four of which he described, one with snapping fingers (*doigt à ressort*). One of his cases resulted from a tendovaginitis crepitans. He believed that stenosing tendovaginitis and cases of snapping finger had the same etiology, genesis, and pathological anatomy. Fischer, in 1923, discussed twelve cases of styloid epicondylitis, six of styloid neuralgia, and one of stenosing tendovaginitis. In the same year Hauck described cases of snapping finger without the presence of stenosing tendo-

vaginitis, some in which the two were combined, and also gave a description of true stenosing tendovaginitis. He concluded that there were no marked differences between the macroscopic and microscopic findings in the latter two groups, the genesis of both groups being traumatic. Eschle presented a résumé to 1924, reporting on one hundred and ten cases, and added nineteen of his own. His patients were all relieved by operation. In one, the stenosis followed a fracture of the radial styloid with callus formation. The following year Kroh published the results of his investigation of fourteen cases of snapping fingers and stenosing tendovaginitis of the flexor tendons of the fingers. Hanson reported an interesting case in 1926, in which he found an incompletely ruptured tendon, following a trauma. He concluded that the tendon sheath was not primarily affected in all cases. In 1927, Eichhoff added five cases to the literature, and suggested a mechanical causation as responsible for some of them, which will be discussed later under etiology. Finally, Winterstein, in 1927, reviewed all accessible cases previously reported, numbering one hundred and forty patients; and added fourteen of his own, four of which were operated upon with complete success. He stated that this condition most frequently affects women of advanced years, the ratio of women to men being approximately ten to one. The average age was fifty-five years, the youngest fifteen. There was no predilection for the right or left hand. Keppler reported two bilateral cases and Winterstein four. Schneider reported fifteen cases. The duration of the disease varied from two weeks to one year. The majority were comparatively early cases. Thirteen received conservative treatment. This consisted of the application of plaster casts to the wrist and thumb, the latter in a position of full extension and abduction. The duration of the treatment was from four to six weeks. Eight of these patients were cured; of the five unimproved cases, two were subsequently operated upon with successful results. The conservative treatment, as advocated by Schneider, resulted in cures in about sixty per cent. of the cases. This surpasses the results obtained by any previous observer. Eschle collected sixty-six cases which were treated surgically; sixty-five cases were cured, and one improved. We are reporting twenty-four cases, twenty in women, four in men. The ages ranged from fifteen to sixty-two years in women, and from twenty-three to fifty years in men. The average age in women was thirty-eight years, in men thirty-nine years.

ETIOLOGY

Stenosing tendovaginitis is encountered most frequently in the laboring classes, which leads to the assumption that it is of traumatic origin. An acute traumatic onset is rather infrequent, having occurred in but six of the author's series. The general impression prevails that the inciting factor must be attributed to a chronic trauma. Cases are reported to have developed after prolonged piano-playing, following the use of a typewriter or adding machine, as the result of excessive writing, washing and wringing

out clothes, chopping wood, carrying heavy objects, farm labor, cutting cloth with heavy scissors, etc. The writer's statistics on occupation are as follows:

Vagina tendinum mm. extensoris digitorum communis et extensoris indicis
Vagina tendinis m. extensoris pollicis longi
Ligamentum carpi dorsale
Vagina tendinum mm. abductoris longi et extensoris brevis pollicis
Vagina tendinum mm. extensorum carpi radialium
Vagina tendinis m. extensoris pollicis longi
Vagina tendinis m. extensoris carpi ulnaris
Vagina tendinis m. extensoris digiti V
Vagina tendinum mm. extensoris digitorum communis et extensoris indicis
Bursa subcutanea metacarpophalangea dorsalis
Bursae intermetacarpophalangeae

FIG. 1

Muscles of the arm. Showing the arrangement of the tendons and their sheaths on the dorsal surface of the hand and wrist (From Spalteholz's Atlas of Human Anatomy).

Females: One piano player, one bookkeeper, one maid, one factory worker, one governess, one dancer, fourteen houseworkers.

Males: Two tailors, one cutter, one grocery clerk.

Some observers assume a gouty or rheumatic origin. Only three of the author's cases gave a positive rheumatic history. No cause whatever could be elicited in four cases. Syphilis and tuberculosis were uniformly absent.

Eschle suggests that the cause of the thickening of the tendon sheath over the styloid process of the radius is chiefly a mechanical one. It is produced by increased friction of the tendons of the two muscles over the long groove at the distal radial end. This friction may be increased quantitatively by exertion. One may assume that the tendon sheath becomes oedematous, which further causes increased friction, and that in this manner a vicious circle is formed, the ultimate result of which is a thickening of the tendon sheath. The friction may be increased qualitatively if the normal smooth osseous base is changed by a trauma.

Eichoff explains the cause of many cases as follows: "Work requiring a constantly repeating movement of the wrist, especially in ulnar abduction, with the thumb fixed on some object. With each movement in this position, the tendons of the extensor brevis and abductor longus muscles become taut over the styloid process of the radius and press upon the tendon sheath, which is unable to avoid the pressure because it lies close to the bone. As a second factor,—during the ulnar abduction of the hand with a fixed thumb, stretching of the entire tendon sheath is produced. The extension of the tendons of the two muscles is strongest when the thumb is in opposition to the hand in middle posture. If the hand with the thumb is now abducted in ulnar direction, then both tendons, and with them the tendon sheath, must be overstretched. A simple experiment will verify this assumption. If one places the thumb within the hand and holds it tightly with the other fingers, and then bends the hand severely in ulnar abduction, an intense pain is experienced on the styloid process of the radius, exactly at the place where the tendon sheath takes its course. The pain disappears the moment the thumb is again extended, even if the ulnar abduction is maintained. In cases of forced abduction of the hand without simultaneous involvement of the thumb, one does not succeed in evoking this pain. Thus repeated overstretching of the tendon sheath results in an injury to the gliding mechanism."

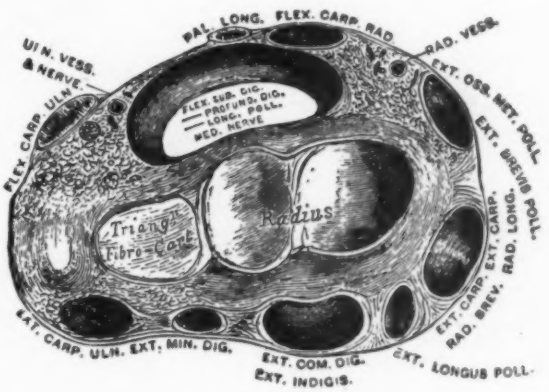

FIG. 2

Transverse section showing the compartments for the passage of tendons at the wrist (From Gray's Anatomy).

ANATOMY

Material for anatomical study of the structures occupying the first compartment on the dorsal surface of the distal end of the radius, was obtained from five recent autopsies. After incising the skin and superficial fascia and retracting the superficial branches of radial nerve and vein, the tendon sheath surrounding the abductor longus and extensor brevis pollicis tendons is exposed. It is about two and one-quarter inches in length. This sheath is strengthened by the addition of some transverse fibers about five-eighths of an inch wide, which are dull, pearly gray in color (ligamentum carpi dorsale). On moving the thumb in flexion and extension, the tendons are felt to glide smoothly back and forth. The proximal end of the sheath is nicked, a fine probe is passed through the sheath and emerges at a nick in the distal end. There is no obstruction encountered. The anterior wall of the sheath is now entirely opened; it is about one-thirty-second of an inch in thickness, lined by synovial membrane. Within the sheath are the two tendons, shiny, pearly gray in color, occupying the common compartment on the outer side of the styloid process of the radius. The radius is grooved and covered by the posterior layer of the sheath. At the margin of the sheath the synovial membrane is invaginated and goes over into the tendon as epitenon. The tendon itself, therefore, is closely connected with the tendon sheath, but in such a manner that in one or another direction a certain capacity for movement is permitted (Mayer and Biesalski). The first compartment is separated from the second by a bony ridge, to which is attached a vertical prolongation of the dorsal carpal ligament.

FIG. 3-A

Schematic drawing showing the dorsal carpal ligament, tendons, and sheaths on the dorsal surface of the hand and wrist.

FIG. 3-B

Schematic drawing showing the ligament, tendon, and sheath viewed laterally.

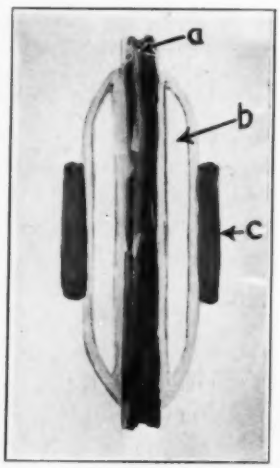

FIG. 3-C

Schematic drawing showing the structures occupying a normal compartment at the dorsal surface of the wrist: *a*. tendon, *b*. sheath, *c*. ligament.

MICROSCOPIC ANATOMY

The inner surface of the tendon sheath is lined by a flattened layer of cells (hereinafter to be designated as "the synovial layer"). Immediately outside this synovial layer is a rather loose, cellular, connective tissue, containing fine thin-walled capillaries and some larger vessels with thin

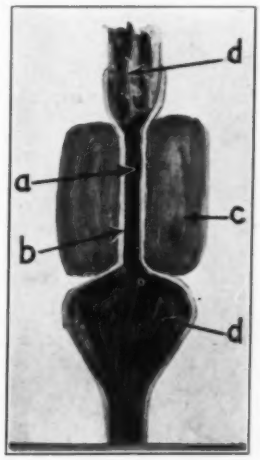

FIG. 3-D

Schematic drawing showing the changes in stenosing tendovaginitis.

a.-b. Constricted tendon and sheath.
c. Thickened ligament.
d. Bulbous enlargements of tendon beyond constriction (Somewhat exaggerated).

FIG. 3-E

Schematic drawing showing a cross section of a normal compartment: *a.* tendon, *b.* sheath, *c.* ligament, *d.* bone, *e.* marrow.

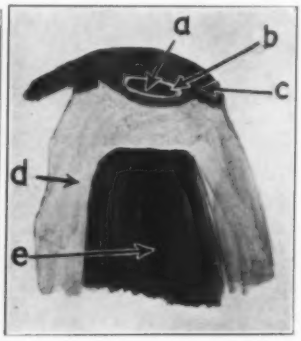

FIG. 3-F

Schematic drawing showing a cross section of the changes in stenosing tendovaginitis: *a.-b.* constricted tendon and sheath, *c.* thickened ligament, *d.* bone, *e.* marrow.

muscular coats (the loose connective-tissue layer). This layer gradually fuses with a very dense fibrous and hyaline tissue which corresponds to the annular ligament (the ligamentous layer). There is no separation between the two latter structures; they apparently fuse imperceptibly with each other. The firm fibrous-like tissue that constitutes the annular ligament is practically avascular, and in its more superficial aspect it is covered by a thin, loose, connective-tissue layer containing blood vessels (the subcutaneous layer). (Fig. 4.)

PATHOLOGY

Reports on the pathologic findings in operated cases reveal striking differences of opinion by various observers. All, however, are agreed on one point,—namely, that the tendon sheath is considerably thickened and that it constricts the underlying tendons, interfering with their normal gliding mechanism. De Quervain describes the synovial surface as being intact, the surrounding fibrous tissue somewhat thickened, without evidences of fresh inflammation, such as round-cell infiltration. The tendons show no gross pathologic changes. He further adds that the success of the operative treatment demonstrates the justification of ascribing the chief

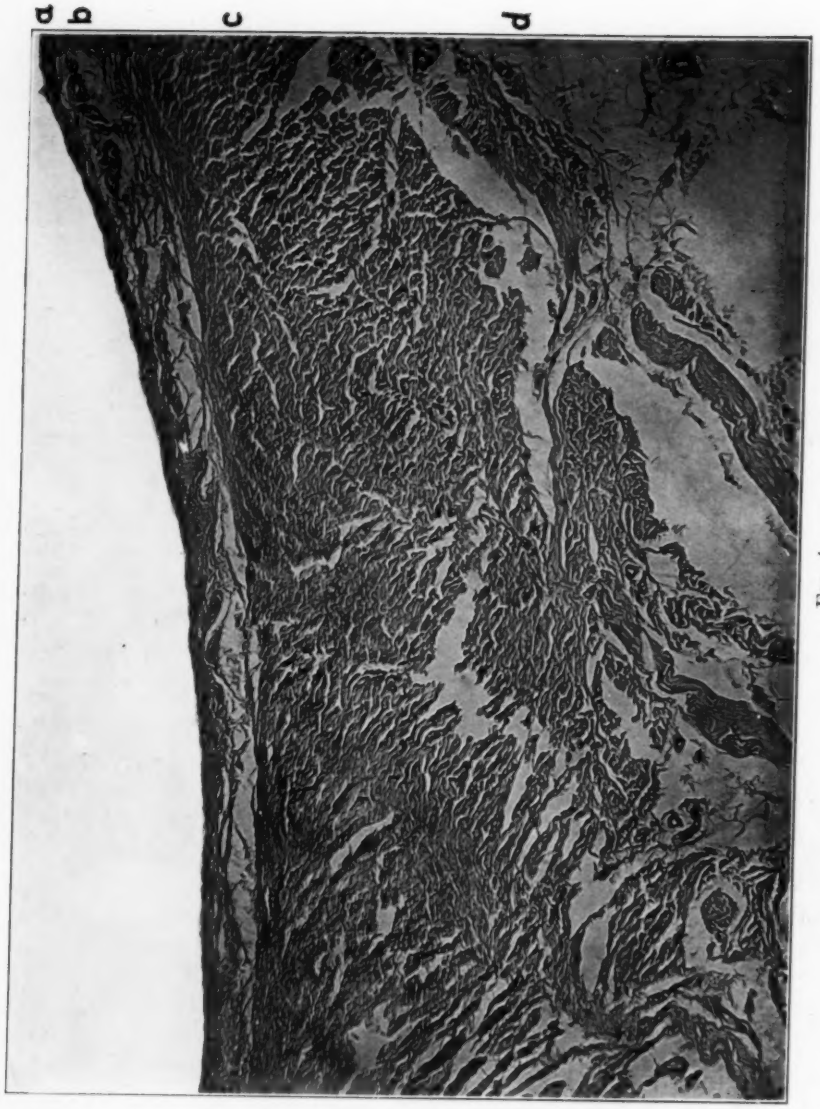

FIG. 4

Photomicrograph of the normal human tendon sheath. Low power.
a. Synovial layer (nearest the tendon). *c.* Ligamentous layer.
b. Loose connective-tissue layer. *d.* Subcutaneous layer (nearest skin).

significance to the thickened tendon sheath fascia. On the strength of the assumption that the pains are caused by constriction of the tendon sheath fascia, he resolved to remove only the external wall of the sheath and concluded that even partial excision is sufficient to effect a recovery. Flörcken and Michaelis were of the same opinion. Welti found the annular ligament lacking its usual glistening appearance, severely vascularized and infiltrated. Marion describes this condition as a serous synovitis because there is an effusion of fluid in the sheath. Keppler made microscopic examinations in twelve cases and found an increase of the rigid fibrous connective tissue, containing numerous vessels, in the region of which a round-cell accumulation of lymphocytic character was found. Undoubtedly, therefore, new blood vessels are produced, from the region of which the new formation of the connective tissue takes its origin. There is also a rapid decrease in nuclei and hyalin transformation. On the strength of these findings, Keppler believes the process to be a chronic inflammation caused by protracted irritation of an aseptic nature. Reschke, in addition to the thickening of the sheath, observed profuse fibrin coagulum upon the longitudinally grooved tendons, which in this area had lost their gloss. Microscopic findings of the thickened tendon sheath showed small-cell infiltration between taut connective tissue. Troell believes that the pathologic process may occur in the tendon, and refers to two cases, one of fusiform swelling, consisting of chronic granulation tissue of the abductor pollicis tendon, and another case in which the tendon was surrounded by a loose tissue, rich in blood vessels, in the ligament compartment.

Nussbaum divided the findings into two groups: The first group shows a considerable increase of connective tissue in the tendon sheath wall, three to four times the normal thickness. The fibers are more condensed than in the normal. The synovial membrane is absent. In the second group, the vessels and nerves in the loose connective tissue of the outer layer are infiltrated with numerous round cells. The middle layer consists of interlacing bands of connective tissue and shows, likewise, a round-cell infiltration of vessels and nerves. Some sections show small, irregular, necrotic areas. The vessels are more numerous on the inner side of this middle layer. The lumen end of the tendon sheath is frequently formed of necrotic masses.

Vischer concludes that in cases of stenosing tendovaginitis the affection always begins with inflammation, which is followed by fibrous changes. Eichhoff states that macroscopically a thickening of the tendon sheath was always found. In general, the tendons themselves show no pathologic transformations. They may be compressed, however, by the stenosis in such a manner that they become separated into fibers.

Although de Quervain stated that this disease occurred only in the tendon sheath of the abductor longus and extensor brevis pollicis tendons, the present writer found similar lesions in other tendon sheaths. There was one instance of involvement of the extensor carpi ulnaris tendon, and one in which the flexor longus pollicis tendon was affected. In another patient

on operation, the extensor longus tendon sheath was stenosed in addition to the usual first compartment structures, and finally the sheath of the extensor longus pollicis tendon was found stenosed, and associated with this lesion there was a ganglion extending into the wrist joint. In the latter case, the sheath of the first compartment tendons was slit, but found perfectly normal. Other observers have also stressed this point. Nussbaum reported involvement of the sheath of the flexor longus pollicis tendon. Hauck described a number of cases with similar lesions in the flexor tendon sheath of the thumb. Vischer described one case in which the extensor carpi radialis longior tendon sheath was affected in addition to the first compartment sheath, and cited another instance of involvement of the sheath covering the flexor sublimus tendon of the fourth finger.

MACROSCOPIC FINDINGS IN AUTHOR'S CASES

In *mild* cases the changes may be very slight. The tendon sheath is about twice the normal thickness, and no inflammatory changes are present. The tendons are thinned out at the point of constriction, and are somewhat larger in circumference beyond this area. They do not glide freely on movements of the thumb. There is seldom evidence of effusion within the sheath. In *severe* cases, the sheath may be very greatly thickened, being three or four times thicker than average, densely fibrous, or even of cartilaginous consistency, and the sheath is brownish or reddish in color. The normal pearly luster is lost. Adhesions may exist between the tendons and sheath, and at times between the tendons themselves. The latter may be flattened and thinned out, at times frayed and covered with granulation tissue. Beyond the point of constriction the tendons often are bulbous. On several occasions the writer observed a division of the first compartment into two halves by a ridge of dense fibrous tissue running through its center, each tendon being supplied with a separate sheath. This bridge naturally diminishes the compartment space and serves as a further mechanical hindrance to the normal gliding function of the tendons. Another condition frequently encountered was a separation of either or both tendons into several strands.

MICROSCOPIC FINDINGS IN AUTHOR'S CASES

In *mild* cases the synovial membrane is thickened, except at the point of constriction, where it is thin or entirely absent. The loose connective-tissue layer is considerably thickened and vascularized; the ligamentous layer is slightly thickened but not vascularized. Only rarely is there a line of demarcation between the loose connective-tissue layer and the ligamentous layer. In *severe* cases the synovial layer is completely destroyed, the loose connective-tissue layer is compressed and thinned out, while the ligamentous layer is markedly thickened and undergoes hyaline and cartilaginous transformation. There is also marked thickening of walls of blood vessels, and cellular infiltration of the tissues, numerous

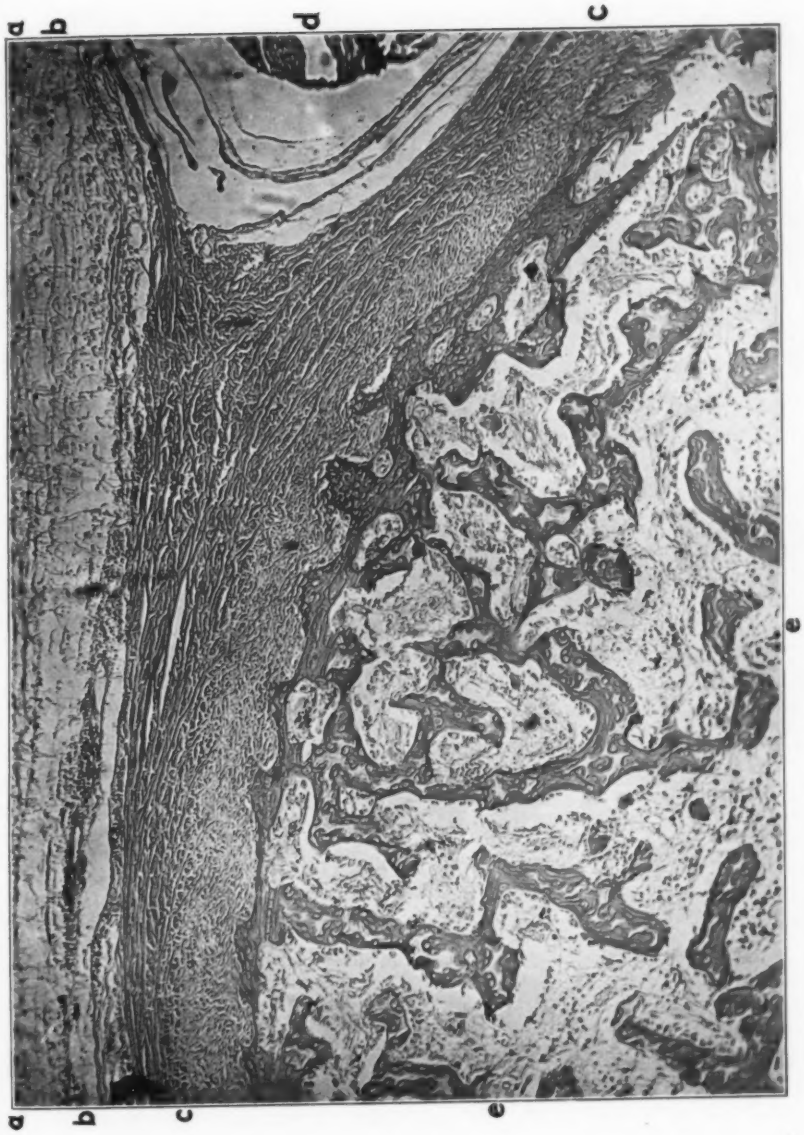

FIG. 5

Photomicrograph showing the normal structures of the first compartment on the dorsal surface of the radius in a rabbit. Low power.

a. Synovial layer.
b. Loose connective-tissue layer.
c. Ligamentous layer.
d. Tendon.
e. Styloid process of the radius.

lymphocytes being present. Between these two types there are many gradations.

ANIMAL EXPERIMENTS

In order to determine whether the lesions of stenosing tendovaginitis could be reproduced experimentally, a study of the first compartment on the dorsal surface of the lower end of the radius in rabbits was undertaken. The anatomical structures, both in the gross and microscopically, were found to closely resemble those found in the human, with but one exception, —namely, that instead of two tendons there was one fairly large tendon occupying this region (Fig. 5). A series of rabbits were then subjected to the following experiments*.

a. Four rabbits were sprayed with ethyl chlorid over the skin covering the radial styloid process. A whole tube of ethyl chlorid was used in each instance. These animals were examined two, four, eight, and ten weeks later.

b. In three rabbits friction with a round wooden handle was applied over the paws for from one to three minutes. Operations were performed two, four, and ten weeks later.

c. Three rabbits were traumatized by means of a metal mallet. Ten, fifteen, and twenty blows were struck. Operations two, four, and six weeks later.

In experiments *a*, *b*, and *c*, care was taken to avoid breaking the skin in each instance. In the following experiments the tendon sheath was exposed by incision through the skin and superficial fascia.

d. In two rabbits, a pledget of cotton dipped in pure carbolic acid was swabbed over the outer surface of the tendon sheath, followed by alcohol. Operation two and four weeks later.

e. In two rabbits, pure carbolic was similarly employed without alcoholic neutralization. Operation two and four weeks later.

f. In one rabbit the tendon sheath and tendon were pinched in several places by an artery clamp. Operation four weeks later and subsequently a second operation six months later.

g. In one rabbit the tendon sheath was exposed, incised, and then sutured tightly over the tendon with silk suture. Operation eight weeks later.

The results were as follows:

In experiments *a*, *b*, and *c*, a lesion closely resembling the changes encountered in stenosing tendovaginitis of humans, resulted in each animal. The pathologic changes varied somewhat in degree only. The tendon sheaths were found thickened, vascularized, constricting the tendons so that the passage of a probe usually met with an obstruction. At times there were adhesions between the tendon and tendon sheath, but in no instance was there any gross injury observed in the tendons themselves. Microscopically, the changes closely simulated the findings in human specimens,—namely, a destruction of the synovial layer, compression of the loose connective-tissue layer, a marked thickening of the ligamentous layer with vascularization (Fig. 6).

In experiments *d*, *e*, *f*, and *g*, the lesions were more decided. The

*All animal studies were carried out with the animals under ether anaesthesia. Operations were performed under strict aseptic precautions.

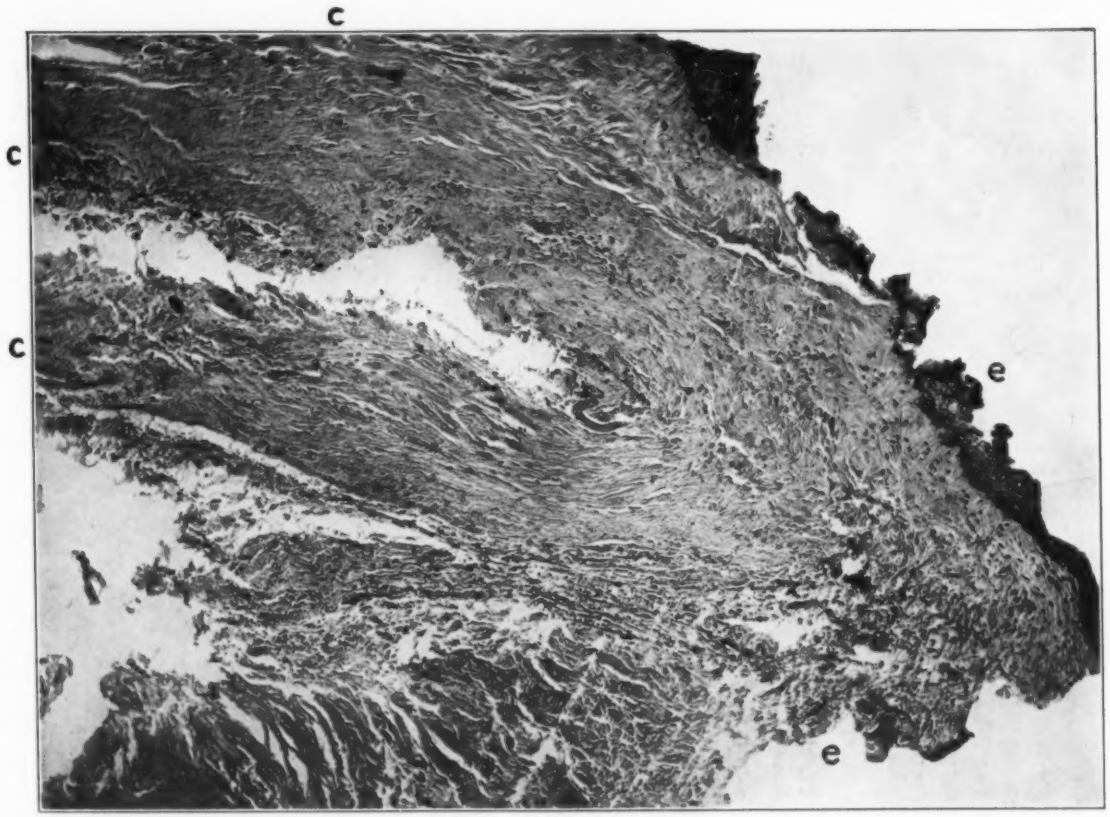

FIG. 6

Photomicrograph showing the pathologic changes in the tendon sheath of a rabbit four weeks after spraying the skin with a tube of ethyl chlorid. Low power. The ligamentous layer is markedly thickened, having undergone fibrotic changes; the synovial and loose connective-tissue layers are practically obliterated. *c.* ligamentous layer. *e.* styloid process.

(Compare with the normal structures as shown in Fig. 5.) Same magnification.

tendons in most of the rabbits were affected to a greater or lesser degree. In mild cases the tendons lost their pearly luster, were covered with granulation tissue, adhesions formed between the tendons and sheaths; in severe cases, in addition to the above, the tendons were often frayed, thinned out in places, and in several cases necrotic changes were produced. The tendon sheaths were greatly thickened, fibrotic, and at times hyalin transformation occurred, with evidences of inflammatory reaction.

From the above experiments, we concluded that stenosing tendovaginitis in rabbits can be produced by thermal, chemical and mechanical traumatization. When the skin remains intact, injury to the tendon sheath is possible, but to the tendon itself, improbable.

SYMPTOMATOLOGY

The onset of stenosing tendovaginitis is usually gradual, occasionally acute, following a trauma or some unusual exertion. The patients invariably complain of severe pain about the tip of the styloid process, radiating down the thumb and up the forearm, and aggravated by movements of the thumb and wrist. Abduction of the thumb and ulnar abduction of the wrist are the most painful movements. Of the rotation movements, supination is more painful than pronation. Difficulty is experienced in grasping objects such as a spoon, fork, knife, or glass. Mild cases may not interfere with work, but severe types are incapacitating. At times the pains are of a neuralgic character, causing sleeplessness. The pain as a rule is not relieved by immobilization, physiotherapy, or medication. Objectively, there may exist a swelling over the region of the tendon sheath, causing obliteration of the anatomic snuff-box. There is distinct tenderness on pressure over the tip of the styloid process and the area immediately adjacent to it. A circumscribed thickening of the tendon sheath may be palpated, and frequently a cartilaginous thickening is felt over the styloid process, situated under the skin, not adherent to the underlying bone, and moving with flexion and extension of the thumb. It sometimes reaches the size of a pea. No grating is felt on movement of the tendons. The pains are increased by passively extending or abducting the thumb, and on making a tight fist. On grasping the patient's thumb and quickly abducting the hand ulnarward, the pain over the styloid tip is excruciating. *This is probably the most pathognomonic objective sign.* Strong flexion of the wrist also produces severe pain. X-ray examinations are uniformly negative. There were no positive Wassermann tests in the writer's series.

DIFFERENTIAL DIAGNOSIS

When one is fully acquainted with the symptoms of this condition, errors in diagnosis are very unlikely. However, the following diseases may have to be ruled out in the diagnosis: tuberculous tendovaginitis, tuberculous osteitis, tendovaginitis crepitans, periostitis, neuritis, arthritis of either gouty, rheumatic, gonorrhoeal, or syphilitic origin.

FIG. 7-A

Photograph of left hand showing swelling over styloid process.

FIG. 7-B

Incision exposing tendon sheath. Probe inserted through a proximal and distal incision.

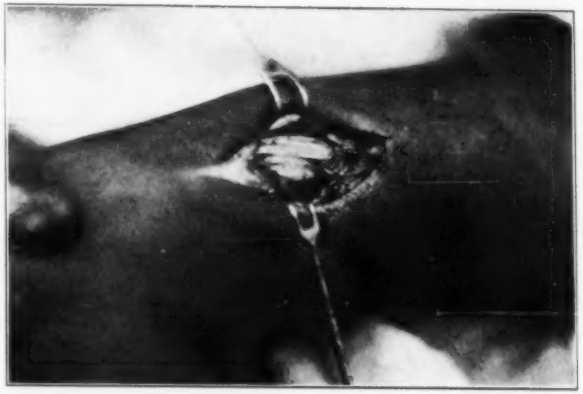

FIG. 7-C

Sheath opened, exposing the two tendons.

FIG. 7-D

Tendons retracted, exposing the posterior half of the sheath.

Fig. 7-E

Entire thickened sheath excised. Probe occupies the position of the tendons.

Tuberculous tendovaginitis is less often primary than secondary, occurring usually by extension from a bone or joint focus. It is characterized by a serous exudate, sometimes forming compound ganglia, occasionally rice bodies may be palpated and there is distinct crepitation imparted to the examining hand. The lesion is rarely circumscribed. Aspiration of the fluid and animal inoculation may be necessary in doubtful cases. Tuberculous osteitis is exceedingly rare, seldom forms a swelling of any special form, and, when it occurs in this region, the bone itself is tender to pressure and not the tendon sheath. Movements of the thumb are not particularly painful. Negative x-ray findings nullify this diagnosis. The author has seen but one case in which the x-ray examination revealed a periostitis of the radius. The absence of friction during movements of the thumb rules against tendovaginitis crepitans. Negative neurologic findings and absence of hyperaesthesia argue against neuritis of the radial nerve branches. The constancy and uniformity of the complaint and the failure of anti-rheumatic therapy speaks against rheumatism. Negative history, blood and x-ray findings aid in excluding gout, gonorrhoea, and syphilis.

TREATMENT

In the acute stage conservative treatment is indicated. Several authors have reported cures. The treatment consists of immobilization in a plaster cast, compression bandage or splint, baking, massage, and diathermy, counterirritants in the form of vesicants applied over the swelling, and potassium iodid internally. If relief is not obtained within a period of four weeks, operative treatment is indicated. Under local anaesthesia, a two-inch incision is made through skin and superficial fascia. The tip of the styloid is at the center of this cut. The small branch of the radial nerve and superficial vein are avoided. A small opening is made into the proximal sheath and a fine probe is inserted in a downward direction; this usually meets with an obstruction. A small nick is made in the distal end of the sheath and a probe inserted upwards. This likewise meets with an obstruction; between the two probe tips lies the stenosed tendon sheath. Some observers merely slit this sheath, others remove a longitudinal strip, and some advise the complete removal of the entire circumference of the tendon sheath. Under any of these procedures the tendons are freed, and the patient usually experiences immediate relief. The superficial tissues are then sutured with fine chromic catgut, the skin with silk, and dressings applied. In about ten days normal function is permitted (Fig. 7-A—7-E).

PROGNOSIS

A review of the literature on end results following operative intervention is impressive. No failures have been recorded; nor is there any mention of recurrences in patients operated on. The writer has recently observed two cases operated upon ten and eleven months previously, still

complaining of pain on pressure over the styloid process. In both instances the tendon sheath on operation was found greatly thickened, inflamed, and cartilaginous in consistency. The technique employed in these cases was the removal of a thin strip of tendon sheath. In view of subsequent experiences the writer feels that removal of the entire tendon sheath would probably have resulted in a cure in both patients.

CASE REPORTS

CASE 1. History No. 13480, April 27, 1927, M. J., female, forty-nine years old houseworker.

Previous history: Had traumatic arthritis of knee two years ago.

Onset: Fell on left hand three weeks ago.

Symptoms: Pain over left styloid process, transmitted to thumb. Aggravated by abducting thumb and by ulnar abduction of hand. Unable to grasp objects. Insomnia. X-ray negative; Wassermann and gonorrhoeal complement fixation negative.

Operation: April 28, 1927, under local anaesthesia, one per cent. novocain. Serous effusion within tendon sheath. Obstruction under annular ligament. No free gliding of tendons. Entire sheath incised. Surface of tendons covered with granulation tissue. Sheath greatly thickened.

Microscopic examination: (S-1931) Some of the synovial layer destroyed in places; marked synovitis elsewhere. The loose connective-tissue layer shows marked vascularization. The ligamentous layer, thickened, consists mainly of fibrous tissue; no vascularization (Fig. 8).

Subsequent history: May 2, 1927, wound healed, primary union. May 9, 1927, discharged from clinic. March 3, 1928, except for occasional tingling sensation in thumb, patient entirely relieved. Uses thumb and wrist freely.

CASE 2. History No. 16326, D. P., fifteen years old, piano player.

Previous history: Negative for rheumatism, gout, lues, tuberculosis. No history of trauma. Cause unknown.

Present history: June 27, 1927, severe pain over left styloid process, worse when practicing piano lessons, especially on attempting to strike octaves. Began insidiously. Treated conservatively at various clinics during past five months, without relief.

Examination: Tenderness over tip of styloid process. Swelling over tendon sheath and obliteration of anatomic snuff-box. Abduction of thumb, flexion of wrist, and ulnar abduction very painful. X-ray negative.

Operation: February 23, 1928, under local anaesthesia, one per cent. novocain.

Findings: Probe met with obstruction within the tendon sheath, the latter about three times normal thickness; cut like cartilage. Tendons do not glide freely. As soon as the sheath was incised, the patient could move thumb without pain. At the point of constriction, the tendons were very greatly compressed, flattened, and frayed, and of a dull grayish color; above the constriction the tendons were bulbous, reddish in color, and covered with granulation tissue. A small independent slit of the extensor brevis tendon occupied a separate compartment which was also stenosed. The constriction was incised.

Microscopic examination (S-2900): The synovial membrane is completely destroyed, the loose, connective-tissue layer is thinned out, the ligamentous layer on its outer surface consists of fibrous tissue which is loose and fatty, and contains numerous vessels, the arteries showing thickened walls. Towards the tendon surface, the tissue becomes more densely fibrous and less cellular, and finally consists of hyaline tissue, containing numerous cartilage-like cells, enclosed in lacunae. The innermost cartilage-like area contains no vessels. It extends in places to the very surface, directly covering the tendons.

FIG. 8

Case 1. Photomicrograph of stenosing tendovaginitis. Low power.
a. Synovial layer destroyed in places.
b. Loose connective-tissue layer shows marked vascularization.
c. Ligamentous layer thickened, consists mainly of fibrous tissue, not vascularized.
Compare with normal structures in Fig. 4. (Same magnification).

Subsequent history: March 3, 1928, primary union. March 16, 1928, no pain on movements of the thumb or wrist. March 30, 1928, free from symptoms. Resumed piano playing.

CASE 3. History No. 11814, L. W., female, colored, twenty-four years old, maid.

Previous history: Cervical glands removed on one side during childhood. Influenza three years ago

Present attack: Began two months ago; onset insidious; no injury. Experienced pain in right thumb and wrist when attempting to grasp objects. Symptoms progressively worse.

Examination: Swelling near tip of styloid process. Tenderness on pressure over swollen area. Abduction and extension of thumb and ulnar abduction of wrist painful. Limitation of flexion of wrist, grip weak. Urine shows trace of albumin. Wassermann negative. X-ray negative.

Operation: September 30, 1926, under local anaesthesia. The sheaths of the abductor longus, extensor brevis, and extensor longus tendons were found thickened, constricting the underlying tendons. Both sheaths were split.

Microscopic examination (S–1364): Synovial membrane missing. There was no evidence of the presence of the loose connective-tissue layer. The specimens consisted entirely of the ligamentous layer, which was markedly thickened, with hyaline and cartilaginous transformation. The blood vessels were thickened; there was cellular infiltration of the tissues with numerous lymphocytes.

Subsequent history: Two weeks later patient was discharged, relieved of all symptoms. Motion in thumb and wrist painless. Able to resume work. Last seen in March 1928, at which time there had been no recurrence.

Comment: Although the lesion was only of two months' duration, this was one of the most severe cases encountered in the series. In addition, it was the first case in which a tendon sheath was affected outside the first compartment. Pathologically, it was one of the few cases demonstrating an extensive cellular infiltration of the affected tissues.

CASE 4. History No. 12629, November 12, 1926, E. N., female, housewife, aged forty-three years.

Previous history: Eight years ago had an appendectomy.

Present history: Five years ago twisted right wrist; since then has complained of pains on the dorsum of the right wrist, ulnar side, numbness and tingling of the fingers of the right hand. The pain is located over the styloid process of the ulna and transmitted down the little finger. Attempts at flexing the little finger produce pain. Grasp of hand is good, but patient cannot lift heavy objects. Is unable to work; even sweeping floors is too painful. Recently suffers from sleeplessness owing to severe pains.

Examination: There is a soft-tissue swelling over the ulnar styloid. Pressure over this area is distinctly painful. Pain increased on flexing little finger and radially abducting the wrist. X-ray negative.

Treatment: Diathermy and immobilization ordered. After two months condition was aggravated.

Operation: January 13, 1927, under local anaesthesia.

Findings: Tendon sheath covering extensor carpi ulnaris, occupying the sixth compartment, considerably thickened. There was extensive granulation tissue formed between the sheath and tendon, and adherent to both structures. This had to be dissected away with a scalpel. The tendon in the constricted area was frayed out and dull looking. The groove in the bone was also covered with granulation tissue.

Microscopic examination (S–1633): In one section the synovial membrane is absent; in another it is thickened, markedly vascularized and covered with fibrin; the loose connective-tissue layer is enlarged and contains numerous round cells, eosinophils, and blood vessels. The ligamentous layer is thickened and very much vascularized. There

is considerable new vessel formation on its outer surface. (This is the most actively reactive specimen in the series.) (Fig. 9.)

Subsequent history: Pains relieved immediately following operation. Discharged from clinic two weeks later; movements of little finger and wrist free and painless. Last seen in March 1928, at which time there had been no recurrence of symptoms. She uses the hand freely, and has been working continually since discharge.

Comments: Contrary to the belief of de Quervain that stenosing tendovaginitis occurs only in the first compartment, this case is positive proof that the lesion may occur elsewhere. The clinical symptoms, operative findings, and microscopic examination are definitely corroborative.

Case 5. History No. 16133, P. J., female, aged thirty-four, houseworker.

Previous history: Diphtheria during childhood. Operated on several years ago for an abdominal tumor.

Present history: Onset in July 1927, with pain over dorsum of left wrist. Following treatment for neuritis, pain grew worse. Swelling appeared on dorsum, pain radiating to finger tips and up the forearm, worse on moving thumb. Hand and forearm tire easily.

Examination: There is a ganglion-like swelling on the dorsum of the wrist, proximal to the joint, more pronounced on hyperflexion and tender to pressure. There is also tenderness on pressure along the extensor longus pollicis tendon. Movement of thumb aggravates the pain. Urine, blood, Wassermann, and x-ray negative.

Operation: February 2, 1928. Nitrous oxide and oxygen anaesthesia.

Findings: Markedly thickened tendon sheath covering the extensor longus pollicis tendon, at least four times the normal thickness, cartilaginous in consistency. A ganglion the size of a grape extended into the wrist joint between the lower end of the radius and scaphoid. The sheath covering the first compartment tendons was opened and found normal.

Microscopic examination (S–2827): The synovial membrane is missing at the constricted portion. The loose connective-tissue layer is thinned and shows some slight cartilaginous metaplasia; the ligamentous layer shows dense fibrous tissue, greatly thickened.

Subsequent history: Pain relieved on the day following operation. February 3, 1928, left hospital. February 15, 1928, resumed work. Last seen March 16, 1928. No recurrence; patient entirely relieved.

Comment: This is another instance of tendovaginitis outside the first compartment. Another point of importance is the fact that marked thickening of the annular ligament may be responsible for ganglion formation, and unless this constriction is relieved by incision, recurrences of the ganglion are likely.

Case 6. History No. 14681, A. B., female, aged thirty, housewife. No history of rheumatism, gout, lues, or tuberculosis.

Present history: Onset six months ago. No history of trauma; cause unknown. Pain over styloid process of left radius, very annoying. Movements of the thumb, wrist, and forearm painful. No difficulty in grasping objects.

Examination: No redness or swelling. Tenderness over the tip of the radial styloid; flexion, extension, adduction and abduction of the thumb painful. X-ray negative; Wassermann negative.

Operation: September 1, 1927, under local anaesthesia. On opening the first compartment, it was found divided in two parts by a dense fibrocartilaginous ridge. Each tendon had a separate sheath. That covering the extensor brevis pollicis was densely fibrous and thickened. As soon as the sheath was incised the tendon showed free gliding function. The tendon itself was of normal appearance. The sheath covering the abductor pollicis tendon appeared normal. It was opened, however, and the cartilaginous ridge was excised. Both tendons then functioned normally. Microscopic findings were those of a mild stenosing tendovaginitis.

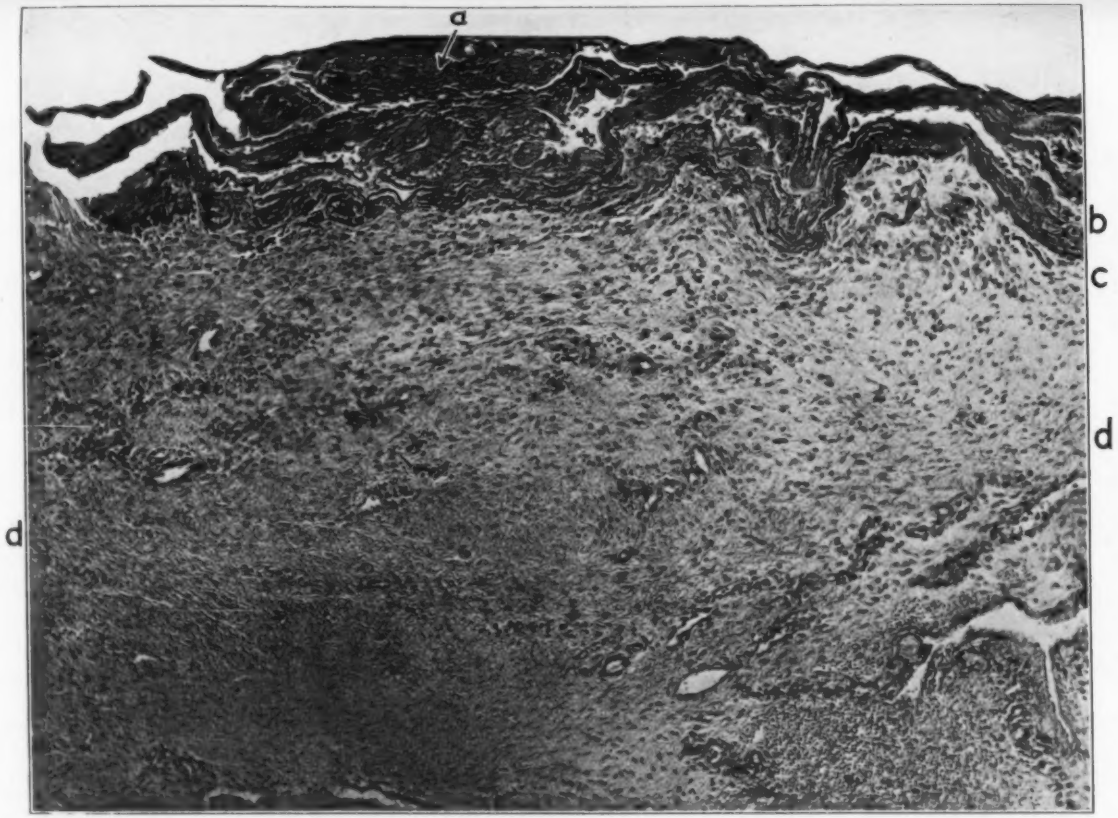

FIG. 9

Case 4. Photomicrograph of stenosing tendovaginitis showing deposit of fibrin on the synovial surface of the tendon sheath. Low power.

a. Fibrin covering the synovial membrane.
b. Synovial layer thickened and vascularized.
c. The loose connective-tissue layer is thickened and contains numerous round cells, eosinophils and blood vessels.
d. The ligamentous layer is thickened and very vascular.

Subsequent history: Discharged three weeks later; symptoms relieved. March 3, 1928, condition excellent, motions of thumb and wrist free and painless. Patient able to perform all household duties.

CASE 7. History No. 13873, L. K., female, forty-five years old, housewife.

Previous history: Negative.

Present history: Onset two months ago. No known cause. Right wrist affected. Typical symptoms.

Operation: June 8, 1927. Extensor brevis pollicis and abductor longus pollicis each occupied separate compartments, a dense fascial septum intervening. The latter was excised, and constriction removed. Microscopic findings were those of a typical mild case.

Subsequent history: Recovery uneventful. On March 5, 1928, a letter was received, stating that patient was entirely relieved of painful symptoms.

CASE 8. History No. 13626, C. St.L., female, colored, aged thirty-three, factory worker.

Previous history: Had facial neuralgia several years ago.

Present history: Onset four months ago. Struck right hand against leg of table. Pain over styloid, extending down the thumb and up to the shoulder. Movements of thumb and wrist painful. Poor grip. Recently dropped an iron while pressing clothes. Cannot sleep at night unless hand is extended over the head.

Examination: Marked swelling over sheath of first compartment. Tenderness on pressure over the styloid process and about one inch below. Limitation of abduction of thumb and ulnar abduction of wrist. X-ray negative; Wassermann negative.

Operation: May 12, 1927, under local anaesthesia. Both tendons occupied separate compartments. Dense fibrocartilaginous ridge divided both tendon sheaths. The sheaths over both tendons were thick, congested, and cut like cartilage. Strip of each tendon sheath removed. Cartilaginous ridge excised.

Microscopic examination (S-1975): Synovial membrane destroyed. The loose connective-tissue layer thickened and vascularized. The outer or ligamentous layer thickened but not much vascularized.

Subsequent history: March 4, 1928. Patient satisfied with operative result. Has no night pains. Movements of thumb and wrist free. Cannot do heavy work. Pressure over sheath painful. In this case complete removal of the sheath, instead of a narrow strip, would probably have resulted more favorably. Patient refuses further intervention.

Comments: The last three cases demonstrate an anatomic anomaly which is occasionally encountered,—namely, a division of one compartment into two halves by a dense fibrocartilaginous ridge. In one of the cases only a single tendon was constricted; n the remaining two, both tendons were involved.

CASE 9. History No. 13536, May 1, 1927, S. L., male, aged fifty years, tailor.

Previous history: Negative.

Present history: Onset one year ago; window fell on right wrist. Suffered from pain on radial side of wrist, transmitted down the thumb and index finger. Could not hold objects.

Examination: There is slight redness over right radial styloid, moderate swelling, obliteration of the anatomic snuff-box. Tenderness on pressure over tip of styloid and first interphalangeal joint of thumb. Limitation of abduction and extension of thumb, flexion and ulnar abduction of wrist. X-ray negative. Treated conservatively for three months, without relief.

Operation: May 4, 1927. Anterior wall of tendon sheath was found greatly thickened and of cartilaginous consistency, contracting lumen for a distance of one-half inch.

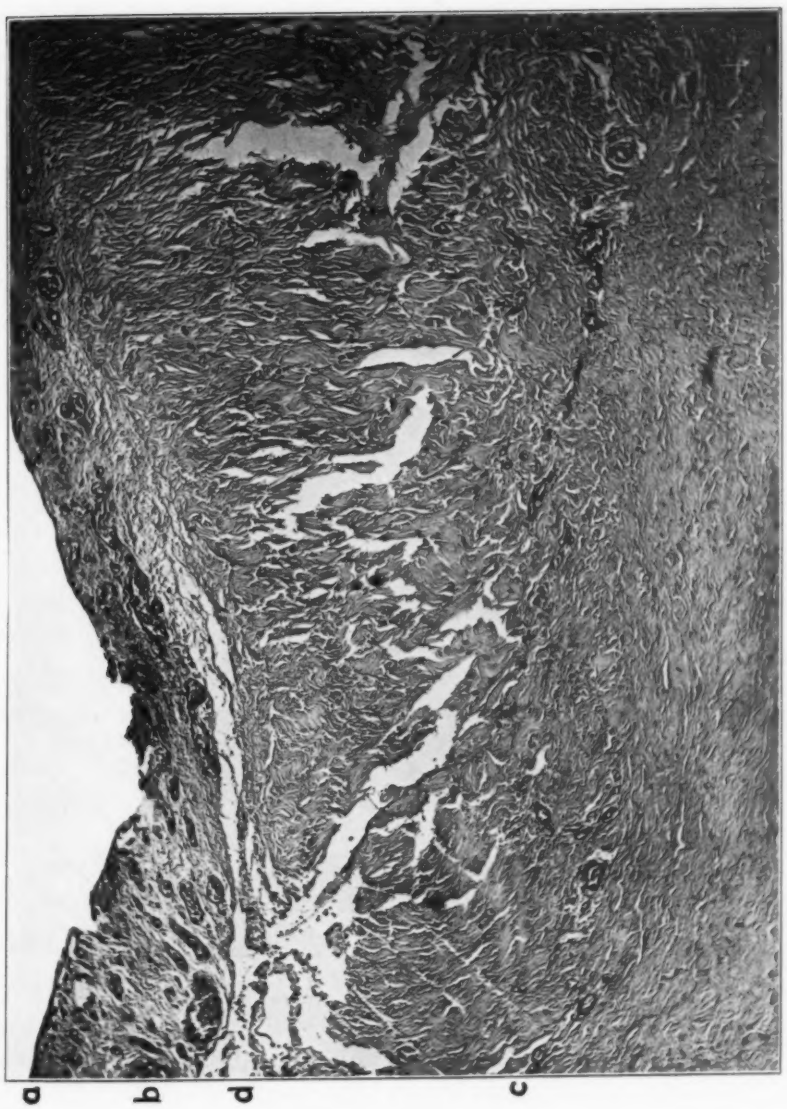

FIG. 10

Case 9. Photomicrograph of stenosing tendovaginitis. Low power.

a. The synovial layer is barely visible.
b. The loose connective-tissue layer is thickened and vascularized.
c. The ligamentous layer is greatly thickened and vascularized.
d. There is a distinct line of demarcation between the loose connective-tissue and ligamentous layers, which is very infrequently encountered.

The tendons were constricted, flattened, and fibrillated. As soon as the sheath was opened, movements of the thumb were free and painless.

Microscopic examination (S-1939): The synovial layer is barely visible. The loose connective-tissue layer is thickened and vascularized, the ligamentous layer is more than twice the normal thickness and is also very much vascularized. There is a distinct line of demarcation between the loose connective-tissue layer and ligamentous layer (Fig. 10).

Subsequent history: Wound healed in ten days. In response to a follow-up letter, patient returned to the clinic on March 8, 1928. He feels better, is able to do ordinary work, and can hold objects securely, but cannot raise heavy objects. There is a tenderness on pressure over the styloid process and pain on ulnar abduction. All other movements are painless.

Comments: This is another instance, the second in the series, in which pain recurred following operative intervention, due probably to the fact that the entire sheath was not removed at operation. The fibrillated condition of the tendons was seen in several other cases where the sheath was greatly thickened, and produced severe constriction of the enclosed tendons. This is also the only case in which there was a distinct line of demarcation between the loose connective-tissue layer and the ligamentous layers.

Case 10. History No. 11867, J. S., female, aged fifty years, governess.

Previous history: Had scarlet fever at twenty-two; denies venereal disease.

Present history: Sixteen months ago patient noticed a snapping sound on moving the right thumb. As time elapsed, the snapping increased and the thumb joints became somewhat stiffened.

Examination: Tenderness on pressure over the flexor longus pollicis tendon at the metacarpophalangeal joint. There was grating in this joint on flexion and extension. There are only fifteen degrees of flexion in the distal phalanx. Extension painful.

Operation: October 7, 1926, under local anaesthesia. The flexor longus pollicis tendon exposed at the metacarpophalangeal joint of the right thumb. A fusiform swelling of the tendon was observed, about one centimeter long. No adhesions between tendon and sheath, but marked constriction of the tendon distal to the swelling, due to thickened sheath. The latter was slit open for a distance of two inches.

Microscopic examination (S-1387): The synovial membrane and loose connective-tissue layer are entirely destroyed. The whole specimen consists of fibrous tissue, markedly thickened, with considerable deposition of calcific material and a metaplasia of the tissue into cartilage (Fig. 11).

Subsequent history: Stitches removed October 18, 1926; wound healed. Movements of thumb free and painless. Last examined March 8, 1928, at which time there had been no recurrences; patient had been attending to her work without interruption.

Comment: This case is included under the heading of stenosing tendovaginitis. The lesion and symptoms were entirely due to a thickened sheath, interfering with tendon function. The snapping was due to the fusiform swelling being forced under the constriction during extension of the thumb. Removal of constriction resulted in relief of all symptoms.

Case 11. History No. 10811, A. E., female, fifty-six years old, housewife.

Present history: Pains in right wrist, near styloid process of radius, for past eleven months.

Examination: Tenderness over sheath occupying the first compartment. Pain aggravated by abduction of thumb, flexion of wrist, and ulnar abduction.

Treatment: Conservative, consisting of physiotherapy and later immobilization in a cast. No relief.

Operation: May 5, 1926. Tendon sheath found thickened, constricting the enclosed tendons. Narrow strip of tendon sheath excised.

Subsequent history: Wound healed by primary union. Discharged two weeks later. Symptoms entirely relieved. Motions of thumb and wrist free. In answer to questionnaire March, 1928, states that there has been no recurrence.

FIG. 11

Case 10. Photomicrograph of stenosing tendovaginitis. High power. Showing markedly thickened fibrous tissue, considerable deposition of calcific material, and a metaplasia of the tissue into cartilage. The synovial and loose connective-tissue layers have been destroyed; the specimen consists entirely of ligamentous layer.

CASE 12. History No. 13742, I. T., male, aged forty-six, tailor.

Present history: Suffering from pains in right wrist for two months, aggravated during the past two weeks.

Examination: Tenderness over right radial styloid, pain on abduction and extension of thumb and on ulnar deviation of wrist.

Operation: May 25, 1927. Tendon sheath thickened, adhesions between sheath and extensor brevis pollicis. Sheath incised.

Subsequent history: There was a slight stitch abscess, which cleared up after stitches were removed.

End result: Excellent function; relief of symptoms.

CASE 13. History No. 13335, L. R., female, forty-five years old, housewife.

Chief complaint: Pain in left wrist and forearm when thumb is extended. Duration eight weeks. No history of trauma.

Examination. Tenderness over left styloid process, aggravated by abduction of the thumb and ulnar abduction of wrist.

Operation: April 13, 1927. Thickened tendon sheath, causing constriction of both tendons. Sheath incised.

Subsequent history: March 5, 1928. Uses hand freely, no pain nor restriction of motion in thumb or wrist. Attends to all household duties.

CASE 14. History No. 13147, R. W., female, twenty-four years old, housewife.

Chief complaint: Pain in left wrist and thumb. Duration five months. No history of trauma.

Examination: Tenderness over left styloid of radius, aggravated by extension of thumb and ulnar abduction.

Operation: March 23, 1927. Sheath thickened, adhesions between sheath and tendons. Sheath incised.

Subsequent history: Discharged two weeks later. Movements of thumb and wrist restored.

End result: Excellent.

CASE 15. History No. 11487, E. B., female, thirty-six years old, housewife.

Chief complaint: Pain over bunions of both big toes. Pain in right wrist on radial side.

Examination: Double hallux valgus. Tenderness over right radial styloid. Restriction of abduction of thumb and ulnar abduction of wrist.

Operation: July 9, 1926. Thickened tendon sheath. Constriction of extensor brevis tendon. Abductor longus normal. Strip of sheath excised.

Subsequent history: Discharged August 13, 1926. Wound healed by first intention.

End result: Excellent.

CASE 16. History No. 13349, M. LeB., female, thirty-nine years old, houseworker.

Chief complaint: Pains over lower end of left radius past six weeks, aggravated by flexing thumb. Cannot grasp objects. No history of injury.

Examination: Tenderness over left styloid. Restriction of abduction of thumb and ulnar abduction of wrist.

Operation: April 14, 1927. Tendon sheath found thickened and cartilaginous in consistency. The tendons do not move freely on voluntary flexion and extension of thumb. Sheath excised. Tendons glide freely. The tendons beneath the constriction are flattened out and of dull appearance. Above and below constriction the tendons are covered by granulation tissue.

Microscopic report (S–1893): Synovial membrane thickened, loose connective-tissue layer thickened and vascularized.

Subsequent history: Wound healed by primary union. Discharged in two weeks. Symptoms relieved.

End result: Excellent.

CASE 17. History No. 13537, B. K., female, fifty-eight years old, houseworker.

Present history: Increasing pains over the radial side of the right wrist for past six months. Disability marked. Grasping movements impossible. Motions of thumb painful and limited. Treated conservatively during this period, with no relief. No history of injury. No cause known.

Examination: Right radial styloid very tender to pressure. Definite circumscribed swelling over lateral aspect of the styloid process. Limitation of extension and abduction of thumb. Restricted ulnar abduction of wrist.

Operation: May 4, 1927. On opening sheath, two drops of cloudy fluid exuded and swelling decreased. Tendon sheath markedly thickened, dull gray in color, and adherent to the abductor tendon. Adhesions also found between the two tendons. Constriction freed. Active abduction of thumb free and painless.

Subsequent history: Wound healed primarily. Patient returned to work two weeks later.

End result: Excellent. Last seen March 5, 1928. Doing all her housework, with no pains and no restriction of motion.

CASE 18. History No. 14546, M. R., female, twenty-five years old, houseworker.

Previous history: No history of rheumatism, gout, lues, or tuberculosis.

Present history: Fell on January 25, 1927, injuring left wrist. Pains transmitted to thumb. Cannot grasp objects. Movements of the thumb or wrist in any direction cause aggravation of the pain. Wrist was in plaster for two months without relief.

Examination: Tenderness over the tip of the left radial styloid. Limitation of extension, flexion and abduction of thumb. Flexion of wrist and ulnar abduction also painful.

Operation: August 17, 1927. Tendon sheath found thickened. Incised.

Subsequent history: September 15, 1927. Normal function. Discharged February 23, 1928. No pain; no recurrence.

CASE 19. History No. 14225, F. S., female, twenty-two years old, dancer.

Chief complaint: Pain in left thumb for many months. No cause known. No appreciable improvement following conservative treatment.

Examination: Tenderness over short extensor tendon of left thumb. Extension of thumb painful. Ulnar abduction limited.

Operation: July 13, 1927. Sheath found thickened. Incised. Tendons in good condition. No adhesions.

Microscopic report (S–2185): Synovial layer absent. Loose connective-tissue layer has disappeared excepting at the periphery of the specimen. The ligamentous layer is extremely thickened, with degeneration of some of the fibrous tissue; calcareous deposition in the outer portion of this layer. There are many round cells surrounding the blood vessels (Fig. 12).

Subsequent history: Wound healed primarily. Discharged twelve days later. Symptoms relieved. February 14, 1928, replied to questionnaire, stating that all her symptoms were relieved.

CASE 20. History No. 15830, T. K., male, thirty-five years old, cutter.

Previous history: Sustained an injury to the right wrist in May 1927. Wrist and back of hand were painful and swollen.

Present history: In July 1927, experienced pains over the right styloid process. When using scissors pains were increased. Unable to grasp objects.

Examination: Tenderness over tip of styloid, extending to thumb. Ulnar abduction painful. Extreme weakness of grip.

Operation: January 5, 1928. Tendon sheath found greatly thickened, interfering with gliding function of both tendons in the first compartment. The sheath was three-sixteenths of an inch thick, and cartilaginous. The tendons were flattened and constricted.

FIG. 12

Case 19. Photomicrograph of stenosing tendovaginitis. Low power. Almost the entire specimen is replaced by the ligamentous layer, which is extremely thickened, with degeneration of some of the fibrous tissue, and calcareous deposition in the outer portion of this layer. There are many round cells surrounding the blood vessels. The synovial and loose connective-tissue layers are almost entirely destroyed.

a. Synovial layer.
b. Loose connective-tissue layer.
c. Ligamentous layer.
(Compare with the normal, Fig. 4. Same magnification.)

Microscopic examination (S-2716): The synovial membrane is thickened. The loose connective-tissue layer is also increased in width; the ligamentous layer shows fibrotic changes with hyalin degeneration at its innermost portion. It is considerably vascularized.

Subsequent history: The patient returned to work three weeks later. Last seen February 27, 1928. Function normal. No limitation of motion in any direction. There is slight numbness over back of thumb and thenar eminence, probably due to cutting some superficial branch of the radial nerve.

CASE 21. History No. 13551, E. S., female, aged forty-nine, houseworker.

Chief complaint: Pain in the right thumb for the past three months, aggravated by extension and abduction. Flexion and ulnar abduction of the wrist also painful. Treated conservatively without relief.

Operation: May 3, 1927. Tendon sheath thickened and cartilaginous. Tendons constricted and slightly frayed; dull in appearance.

End result: Completely cured. Last examined in February 1928.

CASE 22. History No. 15349, V. H. R., female, twenty-seven years old, bookkeeper.

Previous history: No recent illness; no history of trauma.

Present history: Pains in left wrist, radiating down the thumb. Duration six months. Conservative treatment failed to give relief.

Examination: Tenderness beneath the radial styloid tip, aggravated by motions of thumb and ulnar abduction of wrist.

Operation: November 10, 1927. Sheath found thickened and tendons of the first compartment constricted. Strip of sheath excised.

Microscopic examination (S-2518): Disappearance of synovial layer, very little left of the loose connective-tissue layer. Cartilaginous transformation with calcific metaplasia of the ligamentous layer.

End result: Pain relieved; function returned to normal.

CASE 23. History No. 12698, J. C., female, sixty-two years old, houseworker.

Previous history: Sustained an injury to the left wrist, following a fall seven months ago. The wrist became swollen and patient was unable to attend to her household duties.

Present history: For the past six months patient has had severe pains over the left styloid process. Movements of the thumb are painful. Cannot hold objects.

Examination: Marked tenderness on pressure over tip of left radial styloid. Abduction of thumb painful. Ulnar abduction increases pain; flexion of wrist aggravates the condition. There is swelling over the first compartment, with obliteration of the anatomic snuff-box. X-rays negative.

Operation: January 27, 1927. Tendon sheath greatly thickened and cartilaginous. The tendons are tightly constricted, with a fullness distal to the point of constriction. As soon as the constriction was relieved by incision, patient moved thumb freely and painlessly.

Microscopic examination (S-1667): The synovial membrane is visible at the periphery of the section, but destroyed elsewhere. The loose connective-tissue layer is made up of endothelial cells a few layers thick. Some of the cells are spindle-shaped, others polyhedral. The cytoplasm is rather granular. The blood vessels show thickening of the coats in places. A few round cells are seen. The ligamentous layer is extremely thickened, consisting of hyalinized connective tissue, containing in places a bluish-staining, calcific intracellular material. There are no evidences of recent inflammation.

End result: Complete relief of pain and return of function. Last examined in February 1928.

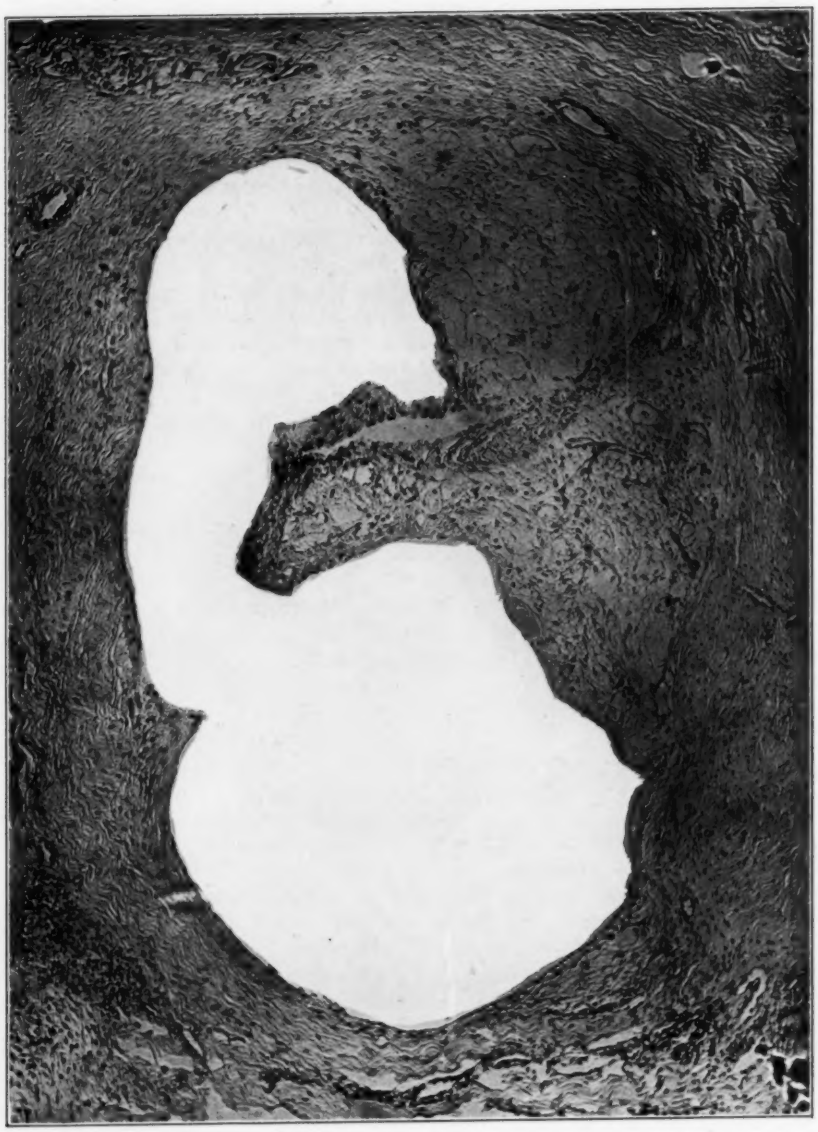

FIG. 13

Case 24. Photomicrograph of an unusual case of stenosing tendovaginitis, showing the presence of a large cystic mass. This has probably arisen as the result of degeneration of the cellular and collagenous tissues, similar in origin to that of a ganglion. Low power.

CASE 24. History No. 17085, J. P., male, aged twenty-three, grocery clerk.

Previous history: Negative; no history of trauma or exertion.

Present history: Began five months ago with pains of a boring character in the left wrist. Not transmitted to thumb or forearm. Is able to grasp objects; movements of fingers and wrist free.

Examination: There is a swelling at the tip of the radial styloid, about the size of a large pea, movable on the underlying bone and also movable on flexion and extension of the thumb. Ulnar abduction painful; all other movements of thumb and wrist free, excepting extreme abduction of the thumb. There is obliteration of the anatomic snuff-box. X-ray negative.

Operation: May 10, 1928. The swelling was due to an extremely thickened tendon sheath of almost cartilaginous consistency; it was easily six times the normal thickness. The tendons were not constricted. The entire sheath was removed.

Microscopic examination (S-3181): The synovial layer is destroyed. There is very little remaining of the loose connective-tissue layer. The annular ligament is markedly thickened, the deeper portion taking on the character of fibrocartilage. The more superficial portion is vascular. There is a large cystic area occupying about a low power field. One of the several cysts in the thickened annular ligament is shown in Figure 13. It is either a lymph cyst or the result of degeneration of the collagenous material.

End result: Patient discharged two weeks later, relieved of pain. Function normal. Last examined in July 1928.

SUMMARY

Stenosing tendovaginitis is a disease frequently encountered. Twenty-four cases were operated upon in a single institution within a period of two years. The laboring classes are most frequently affected. Chronic trauma and overexertion are the most common causes. The disease can be produced experimentally. The common tendon sheath of the abductor longus and extensor brevis pollicis muscles, occupying the first compartment on the dorsum of the radius, is most frequently involved, but any of the tendon sheaths on the flexor or extensor surfaces of the wrist may be affected. Only one bilateral case was encountered, but because the patient refused to submit to operation, the diagnosis could not be definitely confirmed. The pathologic changes are usually limited to a fibrous thickening of the tendon sheath, without evidences of acute inflammatory reaction. There may finally occur calcareous deposits in the sheath. In rare instances, however, the lesion may occur in the tendon itself, and often there are distinct evidences of inflammatory reactions in the peritendinous structures. The pain over the styloid process of the radius may be excruciating, causing disability and interfering with the pursuit of a livelihood. The disease is progressive; not amenable, except in rare instances, to conservative treatment after four weeks' duration; but responds readily to operative intervention, which consists of splitting the stenosed tendon sheath, or in severe cases, the entire removal of the tendon sheath.

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THE HISTOLOGY OF THE POSTOPERATIVE HEALING PROCESS IN CHRONIC OSTEOMYELITIS AND ITS PROGNOSTICATION FROM BIOPSY SECTIONS

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In the surgery of osteomyelitis much bone is necessarily destroyed in the effort to eradicate the disease. The decortication operation removes that portion of normal cortex which immediately overlies the diseased medulla. Deep cavities or depressions on the surface of the bone are the result. When healing is complete the newly formed skin is thin, shiny and closely adherent to the underlying structures. After a considerable time the skin becomes thicker, in many instances fairly free from the underlying tissue. Ultimately the unsightly depression fills very considerably. The effacement is more complete when the defect lies near an active muscle, as in the region of the tibialis anticus on the anterior surface of the tibia. The filling of such a cavity must be due to bone reformation, either normal bone or scar bone, together with a certain amount of connective tissue and possibly subcutaneous fat and skin. Clinical observation from a series of 207 consecutive cases of osteomyelitis shows us that when the granulating surface is clean, quite red, and bleeds upon the slightest irritation, the wound usually heals rapidly. If on the other hand, the entire surface is gray, unclean, and does not bleed readily, the healing in all probability will be delayed. Often both varieties of granulation coexist in patches on the same surface. Invariably the gray area indicates underlying infection, and healing over this area is slow and occasionally secondary operative procedures are necessary. We have also observed, upon uncovering the wound at the end of six or eight days, that the granulations may be readily wiped away with a gauze sponge. At the end of sixteen to eighteen days the tissue is removed with difficulty, while at the end of twenty-four to twenty-eight days a curette or other instrument is necessary to bare the underlying bone.

The questions which naturally arise are:

1. How does bone regenerate in the presence of infection?
2. Is there any effort at reformation of medullary structure?
3. Does cortical bone tissue actually regenerate, or is it replaced by spongy bone and connective tissue?
4. Does periosteum form over the healed bone?
5. Is it possible to prognosticate from biopsy sections of the granulating surface whether healing will be prompt, delayed, or whether a

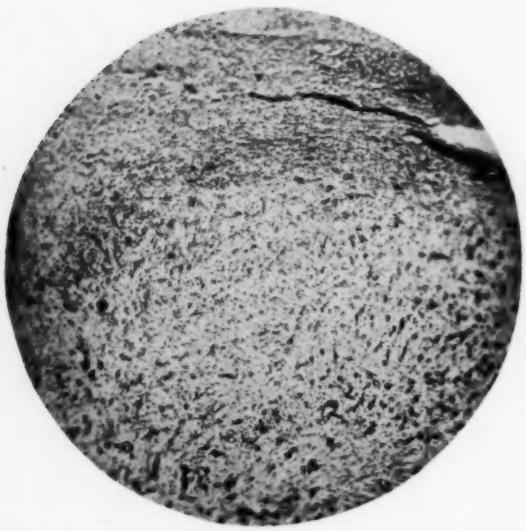

FIG. 1

First zone with healthy granulation tissue. Indicates good healing.

subsequent operation will be necessary to bring about a rapid and complete closure of the wound?

In this series of cases the decortication or saucerization operation was done, removing as much of the diseased bone as was thought to exist and then permitting the cavity to heal by covering it with the vaselin gauze, without any suturing of the skin or muscle tissue according to the method of Orr[1]. In a number of the cases (16) thus treated twenty-two excisions were made from the ulcerated region including the epitheliized border zone and superficial parts of the bone. In all cases evidence of a more or less advanced healing process was present. In a few of these cases such biopsies were taken repeatedly at intervals of four to six weeks, taking the first specimen about thirty days after operation. From the histological study of these specimens removed at different stages of the osteomyelitic healing process, the following picture of the regeneration of bony tissue was visualized.

FIG. 2

Second zone with hyalinized connective tissue and very scanty lymphocytic infiltration. Indicates good healing.

The surgically produced defect in the bone is first covered by an inflammatory granulation tissue derived from the mesenchymatous elements of the bone marrow, periosteum and endosteum. Underneath this coat of granulation tissue a zone of fibrillar, and in the beginning rather vascular, connective tissue is formed. The fibrils of the superficial portion usually run parallel to the surface. With increasing thickness this

tissue becomes more and more oligocellular, oligovascular, and markedly hyalinized, especially in the deeper parts. The strong, firm tissue of this second zone acts apparently as a protective coat for the tissue produced underneath it. The third zone is composed of a more or less loose, rather vascular connective tissue in which strands of hyalinized connective tissue, often located in the perivascular space, are scattered. This takes on later an osteoid character and finally becomes bone through calcification. The osteoid and osseous lamellae are either surrounded by a loose oedematous connective tissue, or in addition to that, by a layer of osteoblasts. In none of the studied cases, in which the first operation dated back a year, was there noted any evidence of cortex production or even a tendency to it. An attempt at cortex formation was apparent only in one case in which an extensive operation had been done upon the tibia twenty months previously. A considerably thickened peripheral lamella of cortical bone structure was found which split up into smaller lamellae of spongy bone type toward the open wound. Even here small spongy bone lamellae were present in the loose connective tissue outside of the strong lamella. As an additional feature in this case, fat tissue was seen in the loose connective tissue of this zone, especially between the lamellae of the spongy bone. This apparently accounts for the

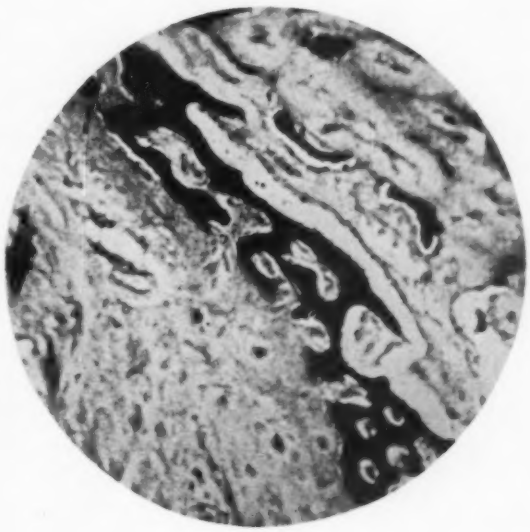

FIG. 3

Third zone with normal bone-forming tissue. Indicates good healing.

FIG. 4

First zone of inflammatory hyperplastic epithelium and moderately infiltrated granulation tissue. Only fair healing prospect.

fact that the skin was movable over the bone. In all other instances where no distinct separation of spongy bone tissue and soft tissue was present, the skin was firmly attached to the bone and not movable.

The regenerative metaplastic formation of spongy bone in chronic osteomyelitis is, according to these observations, characterized by the production of three zones:

1. Granulation tissue zone on the surface, later on covered and replaced by epithelium with a narrow zone of a loose, vascular connective tissue underneath.

2. Protective middle zone consisting of fibrous, hyalinized connective tissue.

3. Ossification zone composed of a loose vascular connective tissue with osteoid and osseous lamellae.

In the course of these investigations one of us (W. C. H.) attempted to predict the healing prospects of the individual cases from the histological structure present in the sections. The establishment of interrelations of this type has become a routinely used and valuable procedure in recent years in the histological prognostication of malignant tumors by numerous workers. The results obtained by this method proved to be very satisfactory from a clinical standpoint as important conclusions upon the therapeutic management of the individual cases were thus obtained.

The prognostic evaluations of the sections were based upon the consideration that the tissues covering the osteomyelitic focus will reflect to a certain extent in their histological structure the inflammatory status of the bone. It was thought that the presence of necrotic or degenerating bone and the persistence of an infectious process in the bone would find histological expression in the existence of inflammatory reactions of an acute or chronic nature in the tissue covering and filling the bony defect and in the indistinct demarcation and incomplete development of its three zones. A marked and predominantly leucocytic infiltration in all three zones, a high vascularity and looseness of the middle zone, and an indistinct demarcation of this zone against the other two zones with rather poor development of the zone of ossification were regarded as prognostically unfavor-

FIG. 5

Second zone of fibrous tissue with moderate perivascular lymphocytic infiltrations. Only fair healing.

able signs. The presence of a mainly lymphocytic reaction extending into the ossification zone and a moderate degree of indistinctness in the demarcation of the three zones was considered as an indication for a thorough curettage of the wound. The complete or almost complete absence of any inflammatory reaction in the three zones and their rather sharp demarcation were interpreted as evidence of good and rapid healing, requiring no change in the therapeutic management. The presence of a dense leucocytic infiltration restricted to the granulation-tissue zone was regarded as a local, superficial reaction which has no direct relation to, or effect upon the regenerative process underneath, except that it might possibly represent an expression of a low resistance against the invasion of skin bacteria. On account of this consideration, cases with such findings were evaluated as not quite as favorable as those with an area of active granulation tissue covered by an almost acellular fibrinous layer.

FIG. 6

First zone with hyperplastic epithelium and granulation tissue highly infiltrated with leucocytes and lymphocytes. Poor healing prospect.

A difference was also noticed in the appearance and arrangement of the squamous epithelium depending upon the condition of the tissue underneath. In cases with favorable course the epithelium appeared to be normal, decreasing gradually in the number of layers and fading out on the surface of the granulation tissue. A narrow zone of loose vascular connective tissue

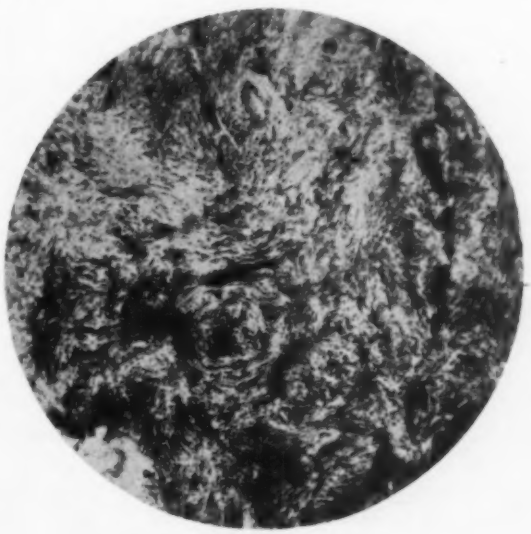

FIG. 7

Second zone with densely infiltrated fibrous tissue. Slow healing prospect.

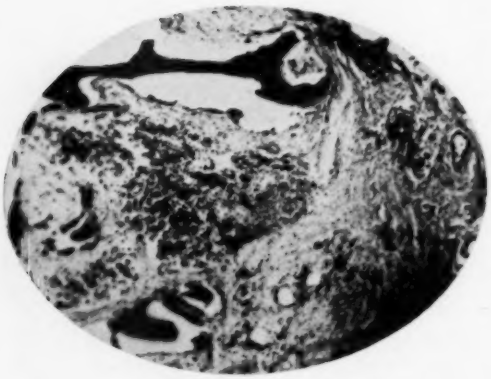

FIG. 8

Third zone with markedly infiltrated bone-forming tissue. Indicates slow healing prospect.

containing small, usually perivascular accumulations of lymphocytes, was found underneath the epithelium taking the place of the granulation tissue in the zonal arrangement. After complete epitheliization this loose structure is later transformed into a strong, fibrillar connective tissue. Epithelium covering more or less markedly inflamed tissue showed, on the other hand, slender epithelial proliferations reaching sometimes into the middle layer. These papillary projections were developed especially at the edge of the ulcer where also a certain degree of atypia of the epithelial cells was noted.

It was furthermore found that the excision did not interfere with the further progress of the healing process. The defects resulting from the biopsy seemed to heal surprisingly well. This observation may find its explanation in the effect of the hemorrhage produced upon the formation of bone which, according to Bauer, is stimulated by blood and bone marrow[2].

The following records may serve as an illustration of the method of prognostication employed.

CASE 1.—Mrs. K., section No. 904/29. Excision from osteomyelitic bone seventy-five days after operation.

A bean-sized piece of white, firm tissue with small pieces of bony tissue adherent to one side is submitted for examination.

A part of the surface is covered by a normal stratified squamous epithelium which sends small papillary projections into the subepithelial tissue. The ulcerated portion is covered by a fibrinous coat containing few leucocytes. The subepithelial tissue and the granulation tissue of the ulcer consist of a moderately thick layer of a loose vascular connective tissue with a scanty lymphocytic infiltration. The middle, well demarcated and wide zone is composed of a strong fibrous, partly hyalinized, but still rather vascular connective tissue which shows only occasional perivascular lymphocytic infiltrations. The third zone is made up of a loose connective tissue with a moderate number of vessels and small islands and lamellae of spongy bone tissue surrounded by osteoid edges.

Diagnosis: Chronic osteomyelitis with very good healing prospects.

CASE 2.—Mr. M., section No. 902/29. Excision from osteomyelitic bone 121 days after operation.

A lima-bean-sized piece of a soft white tissue with small pieces of bone adherent is submitted for examination.

The stratified squamous epithelium shows frequent papillary projections into the subepithelial tissue, where they, through interconnections, sometimes form an epithelial network. Degenerations of the epithelium are present in places evidenced by the

presence of three to five layers of small spindle-shaped or round epithelial cells. The subepithelial tissue consists of a loose, oedematous, vascular connective tissue densely infiltrated with leucocytes and lymphocytes. In places, where the epithelium is defective, it reaches the surface and is covered by a fibrinohemorrhagic coat. The first zone is rather narrow. It is followed by a wide zone of a rather vascular, fibrous, partly hyalinized connective tissue with marked lymphocytic infiltrations, fibroblastic and endothelial proliferations. Toward the depth the tissue is of a looser character and contains osteoid and osseous lamellae and a moderate, but diffuse, lymphocytic infiltration.

Diagnosis: Osteomyelitic tissue with moderately good healing prospects.

CASE 3.—Miss J., section No. 222/29. Excision from osteomyelitic bone fifty-eight days after first operation.

A bean-sized, white piece of tissue is submitted for examination.

A fibrinopurulent exudate covers a somewhat fibrotic inflammatory granulation tissue containing numerous vessels, a dense, mainly leucocytic infiltration and evidence of a marked endothelial proliferation. This zone is wide and goes over without distinct demarcation into a narrow zone of strong fibrous tissue mixed diffusely with a loose, vascular and markedly infiltrated lymphocytic connective tissue. In the deeper portions of this layer small strands of osteoid tissue are present.

Diagnosis: Osteomyelitic tissue with unfavorable curative aspects.

COMMENTS AND CONCLUSIONS

In an attempt to interpret the results of our investigations in regard to the questions raised, the following conclusions may be drawn:

1. The bony defect is filled in by the production of three different zones of tissue formed in succession, namely, granulation tissue, strong fibrous and hyalinized connective tissue, and loose connective tissue with lamellae of osteoid and osseous tissue. The presence of an infection interferes to a greater or lesser extent with the proper formation and arrangement of these structures and therefore greatly retards regeneration of bone.

2. In the sections examined no evidence of a reformation of medullary tissue was found. A loose, sometimes oedematous connective tissue was present between the bony lamellae.

3. In only one of the cases examined an attempt at cortical bone formation was apparent. In this case complete epitheliization of the defect had existed for six months. Cortex formation is evidently a process of a late period of bony regeneration.

4. The same condition was found in regard to the formation of periosteum. Elastic tissue was only scantily present in the tissue covering the spongy bone.

5. While definite conclusions cannot be drawn from the limited number of cases examined, the present findings seem to indicate that a prognostication of the postoperative healing process of chronic osteomyelitis from biopsy sections is possible and renders valuable information in regard to the therapeutic management of the individual case.

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EPIPHYSEAL SEPARATION OF THE LESSER FEMORAL TROCHANTER*

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Epiphyseal separation of the lesser femoral trochanter is a comparatively rare condition, usually seen in children, mostly boys, between the ages of thirteen and seventeen. The writer has recently had the opportunity of treating two cases, one of which proved to be an epiphyseal separation of the lesser femoral trochanter. The second case, clinically considered to be an epiphyseal separation of the lesser femoral trochanter, was seen on roentgen-ray examination to present no bony lesion. In spite of the absence of the bony lesion in the second case, the writer considers it worth while to report both cases together because of the great similarity in etiology and clinical picture presented by the two patients.

CASE 1†. R. H., an apparently healthy, somewhat undernourished colored boy, fourteen years old, while running down a very steep hill on February 27, 1929, was suddenly seized with severe pain in the upper part of his right thigh. He could barely walk the few blocks home, and had been in bed for three days after the accident. The first night the patient experienced moderate pain in his right groin, which prevented him from sleeping well. The next two days he was quite comfortable when resting in bed, and had pain only on attempts at walking. On March 2, three days following the accident, the boy was brought to the Dispensary of the Harlem Hospital at which time he was first seen by the writer.

Examination revealed that the patient walked with a noticeable right leg limp, without evidence of severe pain. In studying the patient's gait, it was noticed that instead of flexing his right thigh in order to bring his right foot forward when his body weight was resting on his left foot, the boy would swing his body backward and in this manner throw his right lower extremity forward. His right thigh was held in slight flexion and external rotation, and his body was somewhat bent forward. There was no swelling or ecchymosis seen over the right thigh. When lying on his back, the boy was unable to raise his right heel from the table. He also was unable to flex his right thigh when sitting on the edge of the table with feet hanging down (negative Ludloff's sign). All passive motions in the right hip joint were perfectly free; but on passive hyperextension of the right thigh, with the patient lying on his abdomen on the table, pain in the region of the lesser femoral trochanter was complained of. External and internal rotation of the right thigh were not restricted and were only slightly painful. There was a marked tenderness on deep pressure over the region of the lesser femoral trochanter in Scarpa's triangle. The tentative diagnosis of epiphyseal separation of the lesser femoral trochanter was made, and confirmed two days later by the roentgenograms (Fig. 1).

Hospitalization was advised but refused, and the patient went home, remaining in bed most of the time. When seen again on March 7, eight days after the accident, the boy walked with a hardly noticeable limp, and without any pain. The patient, lying on his back with the right knee extended, was then able to raise his right foot from the

*From the service of Dr. John F. Connors, Harlem Hospital.

†Reported at the Clinical Conference of the Hospital for Ruptured and Crippled, March 28, 1929.

FIG. 1

Roentgenograms showing epiphyseal separation of the right lesser femoral trochanter. The picture is taken with the hips in neutral position.

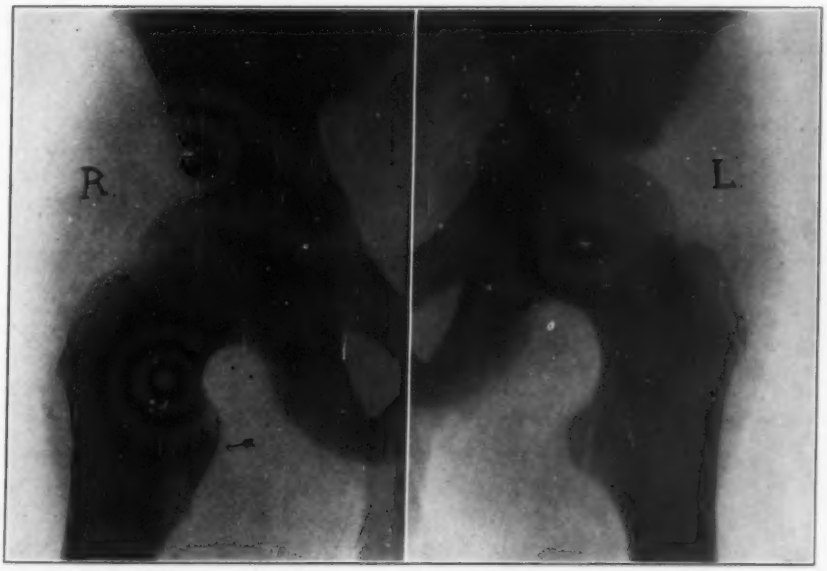

FIG. 2

Roentgenograms showing premature union of the right lesser femoral trochanter about nine months after the injury. Hips are in external rotation, therefore the normal epiphyseal line still seen on the left lesser trochanter is shown better than on Fig. 1.

table, apparently using his rectus femoris, tensor fasciae latae and sartorius muscles as flexors of the thigh. He also could flex his right thigh from the sitting position, but in both instances the power of flexion of his right thigh was considerably less than on the sound side. There was only slight pain still present on passive hyperextension of the right thigh, and the tenderness over the right lesser femoral trochanter, anteriorly, was not so severe as on the first examination.

On March 9, ten days after the accident, the patient walked without a limp but was unable to run. Only a very slight tenderness could be elicited on pressure over the right lesser femoral trochanter, and passive hyperextension of the right thigh caused no pain. Again admission to the hospital was advised, but the patient again refused; a few days later, more than two weeks after the accident, he was located by the Social Service Department, and brought to the hospital where a plaster-of-Paris spica was applied from the level of the axilla down to the middle of the right leg with the right thigh held in about ninety degrees flexion, slight external rotation and slight adduction, and the right knee bent at about a right angle.

The patient was discharged from the hospital at his own request with the plaster spica on, and was referred to the Out-patient Department; but did not appear until April 4, about nine weeks after the accident, when he was again brought in by the Social Service Department. He informed us that he was perfectly well and he himself had removed the spica after wearing it for about two weeks. On examination he was found perfectly free from any symptoms. The roentgenograms taken at this time showed the lesser femoral trochanter still separated.

When seen for the last time on October 19, about nine months after the accident, the patient was found perfectly well and the roentgenograms (Fig. 2) showed a complete bony union of the lesser trochanter to the shaft of the femur.

Case 2. W. P., a colored boy, thirteen years old, was also seen at the Dispensary of the Harlem Hospital on May 11, 1929, complaining of pain in his left groin. On May 8, three days before admission, while competing in races at school, the patient made a sudden stop on reaching the finish. He immediately felt considerable pain in his left groin, and walked home with difficulty.

On examination the boy was found to be somewhat overweight. He walked without any noticeable limp. There was considerable tenderness over the region of the left lesser femoral trochanter anteriorly, and pain in the same region on hyperextension and on extreme internal rotation of the left thigh. The range of active and passive motion in the left hip joint was normal. When lying on his back the boy was able to lift his left heel off the table. He could flex his left thigh from the sitting position, but the power of flexion was considerably diminished. The diagnosis of epiphyseal separation of the left lesser femoral trochanter was made, but the roentgenograms failed to reveal any evidence of bony lesion.

After a few days of rest in bed the patient made a perfect recovery, and was well when last seen, about five months after the accident. The roentgenograms taken at this time also showed no abnormality in the left lesser femoral trochanter, and as a result the case was interpreted by the writer as a partial rupture of some of the fibers of the tendon of the left iliopsoas muscle without avulsion of the lesser trochanter.

The similarity of these two cases in respect to age, etiology, and clinical picture was quite striking. The only difference was in the roentgen-ray findings and in a much quicker recovery of the second patient, which seemed to make the difference only quantitative but not qualitative. If a comparison may be permitted, one might suggest that the relation of these two cases is, to a certain extent, similar to that of a case of the avulsion of the olecranon and a partial rupture of the tendon of the triceps brachii muscle.

Vorschütz[1] could find only five cases of the avulsion of the lesser femoral trochanter in the French literature, and his own case was the sixth reported in the German literature until 1912. Balensweig[2] in a very detailed review of the literature before 1924 found thirty-three cases of avulsion of the lesser femoral trochanter; however in his statistics are included also four cases of fracture of the lesser femoral trochanter in adults (over fifty years), which, it seems to the writer, should be classified separately from the definite clinical entity of epiphyseal separation of the lesser femoral trochanter, occurring, naturally, only in children before the union of this epiphysis to the shaft of the femur takes place. Prati[3] could find only sixty cases of detachment of the lesser femoral trochanter reported before the beginning of 1929.

The center of ossification of the epiphysis of the lesser trochanter usually appears at about the twelfth year and fuses with the shaft of the femur at the age of about eighteen. As Vorschütz points out, the lesser femoral trochanter is completely hidden deep in the upper medial part of the thigh, and is well protected by the thick layer of muscles. All of this makes fracture of the lesser femoral trochanter from direct injury quite improbable.

On the other hand, as was well illustrated by Lewin[4], the iliopsoas muscle, the strongest flexor of the thigh upon the body, and the flexor of the trunk when the thighs are stabilized, is inserted into the lesser trochanter. The powerful traction of this muscle may cause avulsion of the epiphysis of the lesser trochanter as a result either of the sudden strong contraction of this muscle or of weakening of the epiphyseal cartilage due to possible epiphyseal changes. In the majority of the reported cases epiphyseal separation of the lesser trochanter was observed in boys, and the most common etiological factor was a strong muscular contraction during running, racing, or "stopping short".

The patient usually feels a sudden severe pain in the region of the lesser trochanter, and his walking becomes more or less impaired. There is usually no pain on resting, but all active or passive motions, which put some strain on the iliopsoas muscle, cause quite a severe pain. Therefore, the active flexion of the thigh, raising of the trunk from the supine position, hyperextension of the thigh, occasionally internal rotation of the thigh, causing traction on the separated epiphysis, are accompanied by more or less severe pain, depending on the amount and the duration of the lesion.

In almost all the cases there is a strictly localized tenderness over the region of the lesser trochanter anteriorly, in Scarpa's triangle. Tenderness may also be obtained posteriorly, but to a lesser degree, since the lesser trochanter is not as easily accessible, being covered posteriorly by a thick layer of soft tissues.

Ludloff's sign is present in the majority of the cases, but evidently only during the first few days after the injury. In our Case 1, and the case of Oudard and Guichard[5], both first seen three days after the injury, Ludloff's sign was negative. This sign consists in the inability to raise the thigh actively from the sitting position, though there is some active flexion of the thigh in the recumbent position. This is due to the action of the rectus

femoris and tensor fasciae latae muscles, which act as flexors of the thigh in the place of the iliopsoas. In the recumbent position the distance between the points of origin and insertion of the rectus femoris muscle is greater than when the patient is sitting, and therefore this muscle is able to act as a flexor of the thigh in the recumbent position.

The great diminution in the power of active flexion of the thigh constantly observed needs no explanation, as long as the action of the iliopsoas muscle is either completely lost, as in the early cases of epiphyseal separation of the lesser femoral trochanter, or markedly decreased as later during the process of repair.

The writer wishes especially to emphasize one important point observed in the first patient: this is the peculiar gait recorded during the first examination of the patient. This could properly be called "*the gait of deficient flexion of the thigh*".

In the process of normal walking there is a phase in forward progression when the weight of the body is borne on one leg, while the opposite thigh is flexed, mainly through the action of the iliopsoas muscle. In our case, the contraction of the iliopsoas muscle caused pain by pulling upon the separated epiphysis. Therefore, our patient subconsciously tried to avoid active flexion of the thigh, and substituted for the normal phase the above described manoeuver,—sudden swinging of the body about thirty-five degrees backward while standing on the left (healthy) leg. This backward swinging of the body by stretching the anterior part of the capsule of the right hip joint, and especially the ligamentum ilio-femorale (which prevents hyperextension of the thigh) threw the right thigh forward, thus substituting the ligamentous apparatus of the hip joint for the muscular apparatus of the iliopsoas muscle.

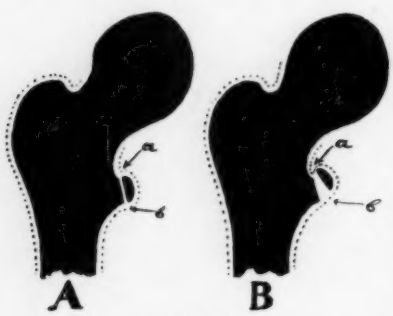

FIG. 3

Showing schematically the periosteal covering of the lesser femoral trochanter. At point *a* the periosteum is only duplicated, but not stretched, in the case of epiphyseal separation. In point *b* it may be stretched or possibly torn. Interrupted line shows the periosteum.

A. Normal femur. *B*. Epiphyseal separation of the lesser trochanter.

The analysis of this gait before any further examination of the patient suggested to the writer that we were dealing with some lesion of the flexors of the thigh; and together with the other findings made the diagnosis possible before the roentgenograms were taken. Last but not least in the diagnosis of epiphyseal separation of the lesser femoral trochanter are the roentgenograms, which should be taken with the thigh in external rotation, because the lesser femoral trochanter becomes hidden by the shaft of the femur when the thigh is rotated internally.

The process of repair usually occurs very quickly, probably due to the fact that the periosteum is only slightly

stretched and forms new bone (Fig. 3). Complete union of the lesser trochanter to the shaft of the femur with premature disappearance of the epiphyseal cartilage as shown in the roentgenograms, takes place in about four months (Oudard and Guichard). Patients with epiphyseal separation of the lesser femoral trochanter usually show a complete symptomatic recovery in four to eight weeks, depending on the extent of the separation. In our Case 1, the patient was practically well in the third week after the injury. He submitted himself to our treatment only after we insisted upon it and removed the plaster spica, against our advice, after only two weeks' immobilization, without any damage to his health. Treatment, it seems, should vary according to the gravity of the symptoms from mere rest in bed with the thighs in flexion in mild cases, to immobilization by means of a plaster-of-Paris spica in the more severe cases. Prognosis is generally good, and all patients recover completely without any complications.

Case 1 gave the impression that rest in bed for two or three weeks in a sitting position with raised back and a pillow beneath the knees in order to flex the thighs, would have been quite sufficient. The application of a plaster-of-Paris spica in this case perhaps was not quite necessary. However, a plaster-of-Paris spica with the affected thigh in ninety degrees flexion, external rotation and adduction, may be quite useful in the treatment of this condition. The iliopsoas muscle, being a flexor, and a slight external rotator and adductor of the thigh, should be completely relaxed by placing the thigh in flexion, external rotation, and adduction. Prati's case is the only one reported where an extensive operative procedure, consisting of wiring of the detached lesser trochanter to the shaft of the femur, was used. The writer's impression is that the above described conservative treatment is always followed by a complete recovery in practically the same period of time as in the case operated upon. Therefore there is no reason to subject a patient to the risk of a complicated open operation.

SUMMARY

1. A case of epiphyseal separation of the lesser femoral trochanter is described.

2. The second case described, though clinically apparently similar to the first, showed no bony lesion in the roentgenograms and is interpreted as a partial rupture of the tendinous fibers of the iliopsoas muscle.

3. Cases of epiphyseal separation of the lesser femoral trochanter are quite rare, occurring mostly in boys between the ages of thirteen and seventeen, as a result of a sudden overexertion of the iliopsoas muscle, mostly during running.

4. Symptoms and signs of epiphyseal separation of the lesser femoral trochanter are pain and tenderness over the lesser trochanter, weakness or complete loss of flexion of the thigh, Ludloff's sign, and the peculiar *"gait of deficient flexion of the thigh"* observed in Case 1.

5. Treatment consists of rest in bed with relaxed iliopsoas muscle or immobilization by means of a plaster-of-Paris spica with the thigh in flexion, external rotation, and adduction; operative treatment is not justifiable.

6. Complete recovery with premature fusion of the epiphysis of the lesser femoral trochanter usually takes place in all cases.

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THE INTERVERTEBRAL NUCLEUS PULPOSUS ITS ANATOMY, ITS PHYSIOLOGY, ITS PATHOLOGY*†

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The "*nucleus pulposus*", the embryologic remnant of the notochord, is that soft gelatinous mass, irregularly ovoid, which is found under pressure in the center of each intervertebral disc. Differentiated histologically from the surrounding tissues, this structure began to attract attention several years ago on account of its primordial rôle in the normal and pathological physiology of the spinal column. Its calcification through pathological processes was not unknown, but a visit to Prof. Schmorl of Dresden revealed to us a new pathological aspect of this "*nucleus pulposus*", — *i.e.*, its migratory character. This article proposes to gather scattered opinions (see bibliography) and to establish, or to create if need be, for that structure an anatomical, physiological, and pathological entity.

ANATOMY

The "*nucleus pulposus*" (of German origin) is the inadequately limited center, gelatinous in substance—under pressure—enclosed in the center of each intervertebral disc. To understand thoroughly the various diseases of this disc, it is important to recall the structure, not only of the disc itself, but also of the adjacent vertebral surfaces.

1. The disc is composed of a peripheral fibrous ring ("*annulus fibrosus* or *lamellosus*"), with a soft central substance. The annulus is formed by numerous fibers, solidly and tightly interwoven, which are inserted deeply in continuity with Sharpey's fibers into the compact and bony zone forming the outside of the vertebral surfaces. This fibrous ring has a few cartilaginous and conjunctive cells. In the smaller peripheral zone, a fine fibrous netting, not so tightly woven, is found, forming a sort of matting, loosely connected to the vertebral surfaces. The "*nucleus pulposus*", situated in the center, or still more often at the juncture of the middle third or of the posterior (lower) third, is a gelatinous mass under pressure, of a flattened bean shape, formed of very loose fibrous tissues (saturated by a liquid), and a few cartilaginous cells, and containing some remnants of the primitive cord. (These cells contain clear protoplasm, sometimes multinuclear.) On one side of the meniscus the nucleus may develop a hernia, thus proving the pressure.

2. In the adult, the adjacent (upper and lower) vertebral surfaces have a very characteristic aspect. There is seen (Fig. 1) on the periphery,

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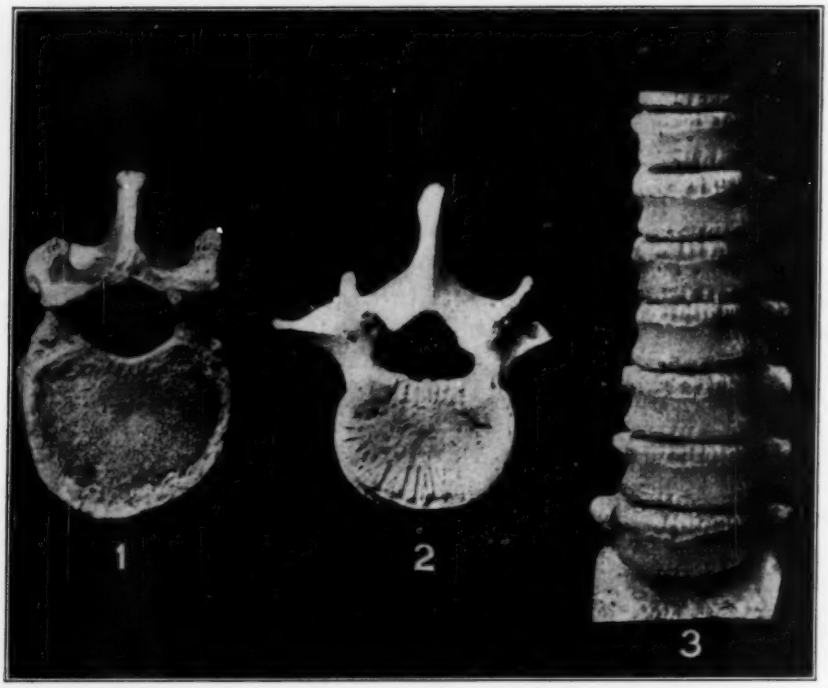

FIG. 1

Left to right (specimens of Schmorl):
1. The vertebra of an adult. On the periphery, a raised, compact, bony surface; insertion of the "*annulus fibrosus*" of the disc. At the center, covered by a cartilaginous coating, is a perforated bony plate (disc), the holes being smaller in the region of the nucleus.
2. The vertebra of an adolescent. Here, in contrast, the center section is raised (practically void of holes). On the periphery is a zone of radiated furrows (the zone of the epiphysial crown is not shown here).
3. Front view of peripheral furrows.

a compact, smooth, bony zone, three to four millimeters in width, wider in front than in back, slightly higher than the central bony tissue (2 m.m. higher in back) and slanting toward the center. Its central limit is irregularly circular. In this zone the fibers of the "*annulus fibrosus*" are strongly inserted. In the interior of this compact ring, the vertebral surfaces take the form of a bony plate perforated by many holes (*Shlussplatte*). Two zones are evident: a peripheral one, with fairly large holes, and a central one with small openings corresponding exactly to the seat of the "*nucleus pulposus*"; it is on that surface, denser and more restricted, that the nucleus rests and moves (*Druckschwankung*). The bone marrow comes to the level of these holes, and by diffusion its vessels provide for the nutrition of the external cartilage, and for that of the vertebral disc—this structure being devoid of capillary vessels. The perforated plate (*Knorpelplatte*) has a cartilaginous covering, which, however, does not cover the compact peripheral zone. This hyaline cartilage adheres to the bony plate through

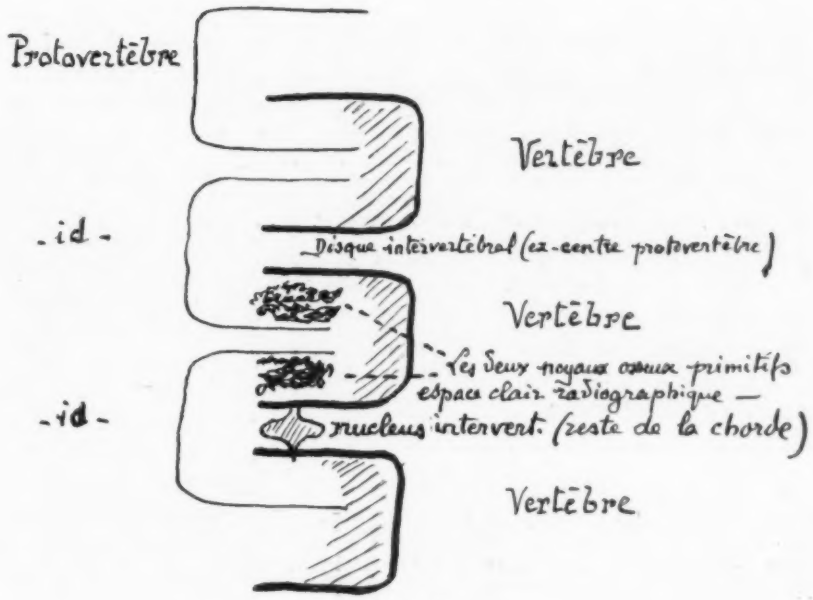

FIG. 2
Vertebrae and protovertebrae.

a thin calcified coating, which, not being continuous, is also perforated, corresponding to each hole in the bony vertebral plate. On its edges this thin cartilaginous plate is continued to the internal limit of the compact peripheral tissue with the "*annulus fibrosus*".

DEVELOPMENT

The embryonic cartilaginous vertebra is not derived directly from the protovertebra, but is so formed that one cartilaginous vertebra includes the caudal half of the preceding protovertebra and the cephalic half of the following (Fig. 2). The interval between two protovertebrae forms the anteroposterior canal, which, opening in the posterior face of a vertebral body, contains the nutrient vessels, and separates for a time the two original bony centers. This interval shows plainly for a long time in radiographic examinations. The intervertebral disc, however, corresponds to the center of the protovertebra, and holds in its center a portion of the central cord, which in turn forms the nucleus (Fig. 3).

The increase in length,—*i.e.*, in height, of a vertebral body is produced through the process of enchondral ossification. The sides adjacent to the disc present a fairly thick cartilaginous covering, which overhangs the anterior edges of the bony tissue, forming, as shown in radiograms, a distinct notch at the anterior angles of the vertebral bodies—it is plainly demonstrable at the age of seven or thereabouts—(Fig. 4, *2*). At that age the inferior and superior surfaces of a vertebral body are higher in the center

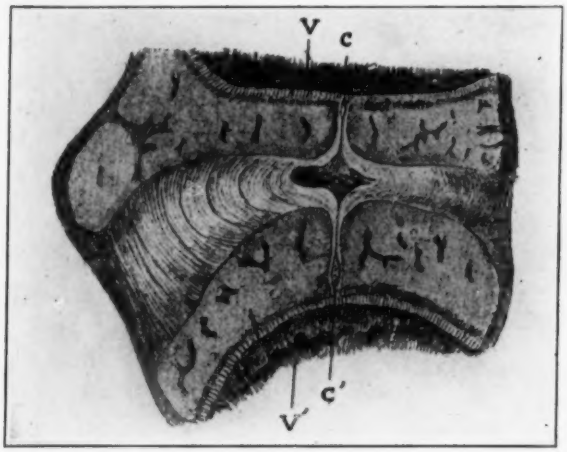

FIG. 3

Cross section (anteroposterior) of two vertebrae and of the intervertebral disc between them in a human embryo (Kölliker)—*V V'*, vertebral bodies; *c*, dorsal cord swollen inside the intervertebral disc; *c'*, dorsal cord inside vertebral bodies. (From Poirier's *Traité d'Anatomie humaine.*)

than on the edges, in contrast to that of the adult; for, while in the adult the edges are higher — compact and smooth—those in the child and adolescent bend gradually downward toward the periphery of the vertebral body, and present regular furrows one to two millimeters in depth, which insure the adherence of the epiphyseal ring and prevent any natural sliding (Fig. 1). Attention should be called to the fact that the epiphyseal points appear as early as eight years of age, and that the ossification is usually completed at twenty-four. Poirier in his "*Traité d'Anatomie*" observes that in man: "These two plates (flat discs) are always very thin at the center, so much so that occasionally they appear as two bony rings". Only the latter part of the above statement is accurate, according to Schmorl, whom we must believe, owing to his wealth of material and the great precision of his observations. He states that he has never observed any epiphysis forming a complete disc, but always in an annular shape, and his observations are confirmed by Schulthess and Hans Virchow.

PHYSIOLOGY

Inside this disc, in the center of a compact fibrous ring and between two bony wafers, protected by a cartilaginous coating, is a gelatinous round mass under pressure, the "*nucleus*". Its shape and position can be slightly altered, and it acts as a spring to keep the vertebrae apart (Fig. 5). If pressure is applied to the intervertebral disc (Roux's experiment), the following happens: either the vertebral surface is depressed or the fibrous ring bursts, and if at any point the cartilaginous covering is perforated, the fibrogelatinous tissue of the disc or nucleus seeps into the spongy tissue, forming a button, the size of which ranges from a pin's head to a small pea. Such are the characteristics of the nucleus, a structure under pressure (a shock absorber), transforming and modifying the force of strain. Thus Roux's experiments indicated what Schmorl demonstrated so conclusively later: that the cartilage protects the vertebral tissue against the nucleus and,

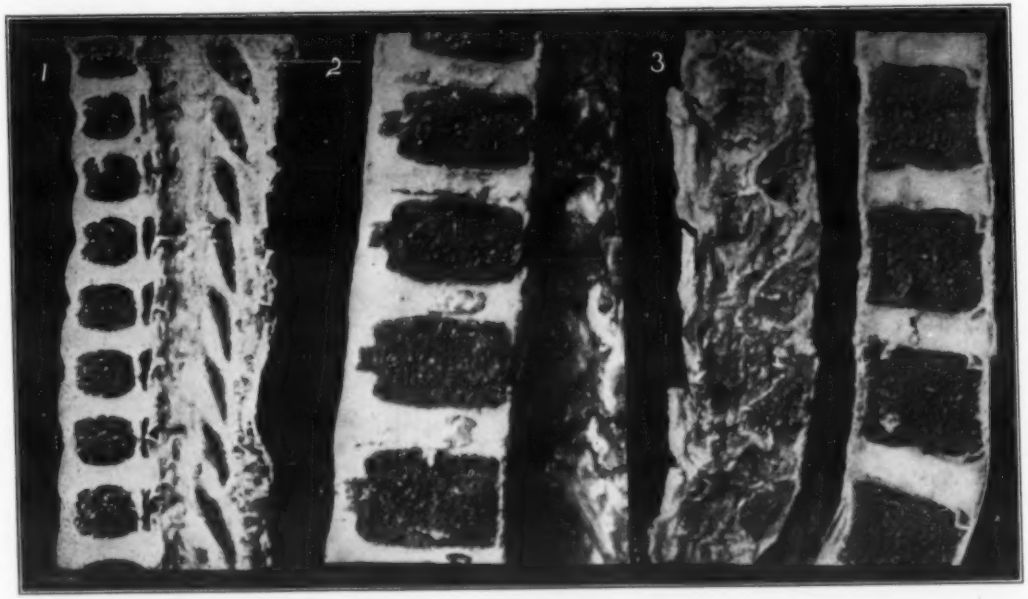

FIG. 4
Various stages of ossification of the vertebral bodies (Schmorl).

FIG. 5
The nucleus as a shock absorber.

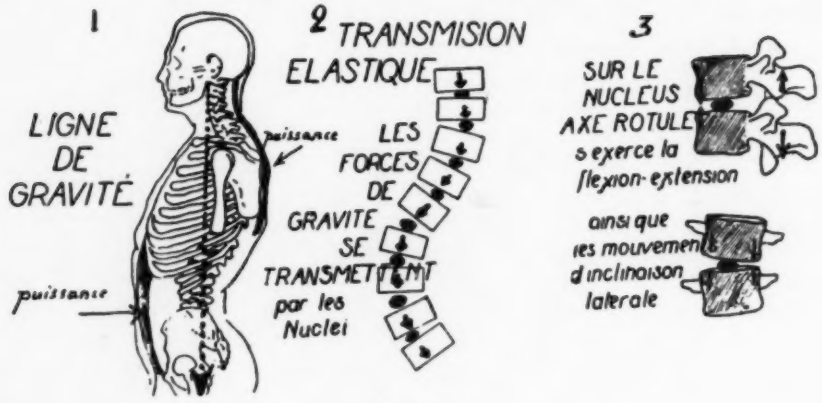

FIG. 6

Weight transmission and rôle of the nucleus.

moreover, one may say that it also protects the tissue of the disc against infection. We have personally established the following physiological points. The nucleus acts as a true bearing inserted between two adjacent bodies. It is on the nucleus that movements of flexion and extension as well as lateral movements (first experiment, Calvé-Lelievre) can be resisted with elasticity, which, as the writers have shown, would be the case in movements in all directions if they were theoretically possible (that is, considering the column as isolated), but which are not possible due to the formation of the column. The posterior intervertebral articulations, owing to the peculiarities of each cervical, dorsal, or lumbar segment, limit somewhat the movements of the vertebral column, so that, for instance, in the lumbar region, the segment of flexion, extension, or lateral movement is quite incapable of any rotation, while the dorsal region, incapable of hyperextension, but capable of a limited flexion, can, in its superior section, rotate very extensively. Though unimportant in itself, the above description confirms the importance of the nucleus as an axis for the movements (Figs. 6

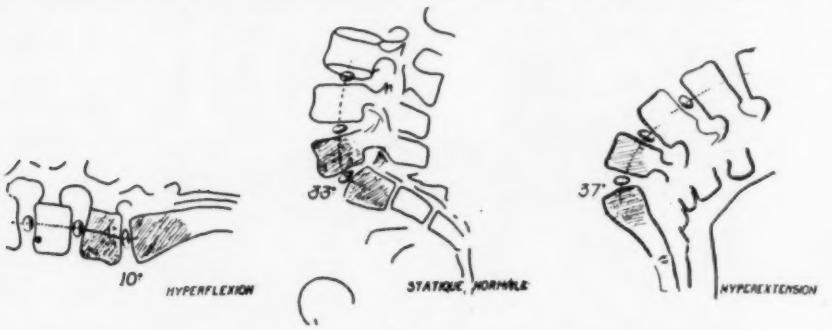

FIG. 7

Movements of flexion and extension acting on the nucleus as on a ball bearing. Notice, for instance, that the forward part of the fourth lumbar intervertebral disc is noticeably compressed by flexion, while the rear is compressed by hyperextension (Calvé).

and 7) which, under pressure, provides for the elasticity of the disc, and transmits, absorbs, and equalizes pressure.

PATHOLOGICAL PHYSIOLOGY

First Form: The nucleus is destroyed.

As previously stated, the "*nucleus pulposus*" is the medium of transmitting pressure from one vertebra to the next. Upon closer examination, it is noticed that the flexible sinusoidal column obeys the law of elastic transmission. That is to say, on the surface of each disc a pressure force will be noticeable on the concave side, and a depression force on the convex side. These forces counterbalance each other, but the force of gravity persists on the nucleus, which represents the transmission of the weight from one vertebra to the next by the intermediary of the nucleus axis (Fig. 8).

What happens if the nucleus ceases to exist? At one point, on the surface of the injured disc, the elasticity disappears and the transmission of forces then takes place through a non-elastic and curved column, so that pressure is greatest on the concave side (in other words, on the part of the column near the center of gravity). Such is the law of transmission of forces through a non-elastic curve. However, pathological disorders will vary according to the nature of the lesions. For instance, in Pott's disease, in which the invasion of the disc equals the physiological suppression of the nucleus, a certain compression of the disc is soon noticeable (anterior in the dorsal, total in the lumbar, and posterior in the lumbosacral region). Furthermore, the bearing having been destroyed, a new axis of flexion appears,

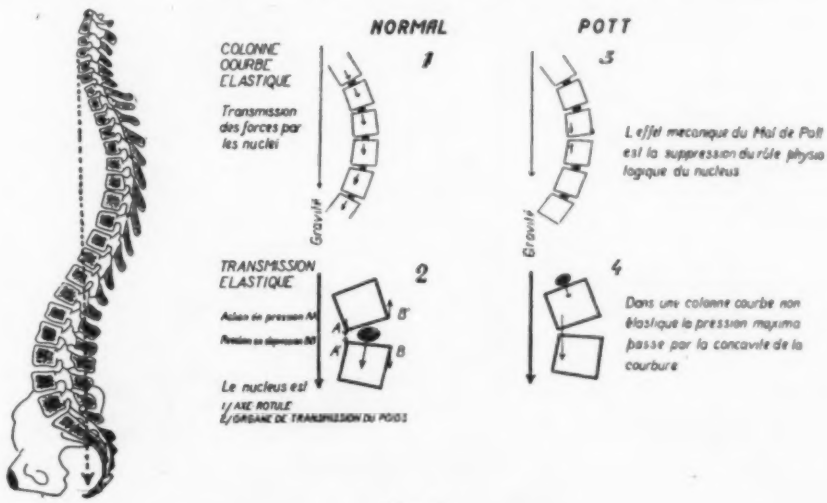

FIG. 8

Line of gravity.

In elastic transmission, the weight is transmitted through the nucleus, pressure and depression compensating (Galland and Las Cases). In the case of lesion of a disc (non-elastic transmission), the maximum of pressure rests in the concavity (Galland and Las Cases).

—*i.e.*, the top of the articular apophysis of the under-adjacent vertebra (Fig. 9). The flexion does not take place, however, without bringing about the dislocation of the intervertebral articulations. In the dorsal region, they are so set that the more advanced the state of destruction, the sharper will be the curving. In the lumbar region, on the contrary, the possibility of this vertical sliding through a certain loss of substance allows a settling of the posterior portion, thus correcting the curve of the anterior section. Be that as it may, friability of the bones and the disappearance of the cartilaginous part of the vertebral surfaces in contact result, during the course of the disease, in a compressive ulceration through contact of the vertebrae. The vertebrae "wear out", rubbing one against the other, before the process of cicatrization, and the vertebrae incline one toward the other, seeking a point of actual contact (Pott's disease). Other processes may be observed. In some affections, such as the hernia of the nucleus into the spongy tissue (Schmorl) and certain other affections, one may notice a progressive transformation of the nucleus,—*i.e.*, a disappearance of the elasticity of the disc. In such cases the bony surfaces of the vertebrae in contact still preserve their resistance, the cartilaginous covering is almost intact. If split at some point, the nuclear hernia which may have seeped through is soon stopped by a peripheral process of bony sclerosis. In such cases the opposing surfaces of the adjoining vertebrae will not ulcerate

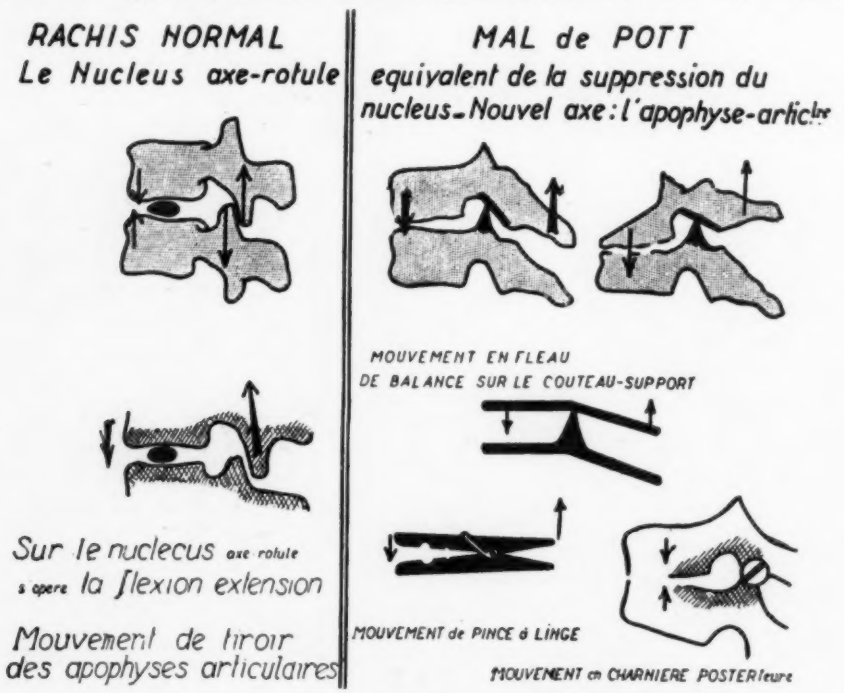
RACHIS NORMAL
Le Nucleus axe-rotule
MAL de POTT
equivalent de la suppression du nucleus. Nouvel axe: l'apophyse-articulaire
MOUVEMENT EN FLEAU
DE BALANCE SUR LE COUTEAU-SUPPORT
Sur le nucleus axe rotule s'opère la flexion extension
Mouvement de tiroir des apophyses articulaires
MOUVEMENT de PINCE à LINGE
MOUVEMENT en CHARNIERE POSTERIeure

FIG. 9

The axis of normal flexion-extension is at the level of the nucleus. If the disc is destroyed, a new axis appears,—the articular apophysis (Calvé and Galland).

(as in Pott's disease), but little by little, with decalcification, they become cuneiform, their lower part corresponding naturally to the concavity of the curves (center of maximum pressure in non-elastic transmission). Such is the case in kyphoses with dented discs in the adolescent, also in certain senile kyphoses (Fig. 18).

Second Form: The nucleus not being destroyed, it preserves all its pressure.

In case of a softening of the bones, as in osteomalacia or certain localized osteoporoses, it may happen that the resistance of the bony tissue is less than the pressure of the nucleus and the vertebrae are then crushed between the adjacent discs and become lenticular, biconcave (like the vertebrae of a fish); the discs swell and become spherical (Fig. 15).

Third Form: The nucleus not being destroyed, not only preserves its pressure but also its slight mobility and possibilities of progressive displacement.

Under some influences, such as a malposture, the discs become cuneiform, being open on the convex side of the curve. In such cases, should the posture persist, the nucleus shifts little by little toward the more spacious part of the intervertebral disc, and it is then noticed to move forward, as in spontaneous or therapeutic lordosis, to compensate the kyphos in Pott's disease. We have observed the nucleus to move laterally to the top of the scoliotic curve, and to be luxated backward, as in some very peculiar kyphoses which we have been able to individualize (Figs. 12, 13, 14).

The normal position of the nucleus has been noted above. May we recall that it is found at equal distance from the anterior edge of the vertebral bodies and from the sliding surface of the articular apophyses (the latter being the object of movements of tension during flexion and extension, the force of which is directed on the nucleus). It can be readily seen that such a disposition of the nucleus is very favorable to the successful execution of any movement of flexion and extension. But such is no longer the fact in case of nuclear displacement, and particularly with anterior or posterior nuclear luxations. In such cases the movements are checked by the nucleus acting as a

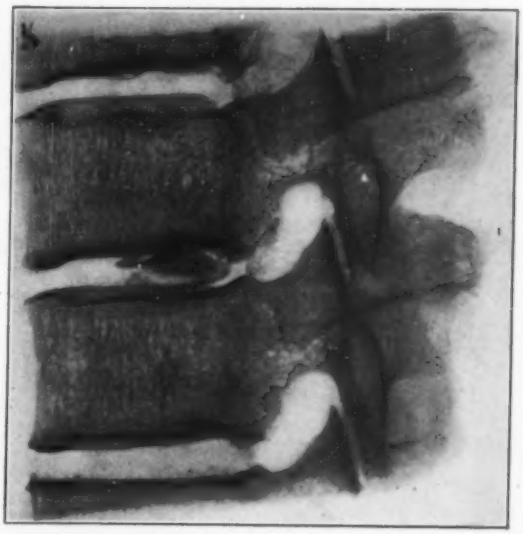

FIG. 10

Calcification of the "*nucleus pulposus*" such as described by the authors in 1922. (Radiographic plate from Schmorl.)

block. Even if such a result is desirable (as in the case of therapeutic lordosis, compensating the kyphos in Pott's disease, for it renders permanent a correction obtained with so much difficulty), it is most harmful in sclerosis, especially in cases of kyphosis with a posterior nuclear luxation which has become absolutely irreducible.

PATHOLOGY

It is not the intention to include in our pathological statement all the diseases of the disc, but only those in which the rôle of the nucleus is particularly striking. Therefore, only the following will be described:

1. Calcification of the nucleus.
2. Posterior displacement of the nucleus.
3. Spherical discs and vertebral osteoporoses.
4. Intraspongy nuclear hernias.

1. *Calcification of the nucleus* (*Fig. 10*).

This affection is of but mediocre interest, but is described first since it presents a peculiarity of its own,—*i.e.*, the possibility of radiograms being taken, which locate the nucleus. We believe we were the first to describe such a lesion (January, 1922). Breton more recently has published the report of a new case (May 5, 1929). It was observed by Barsony and Polgas, and anatomically studied by Schmorl. It occurs mostly in elderly patients, sent to a specialist for examination, with the diagnosis of Pott's disease; but no stiffness is noticeable, and the radiogram reveals the diagnosis, showing as it does the normal position of the nucleus, a homogeneous shadow with a long oval shape. It is an extremely rare affection. Anatomically, the nucleus has become more dense, of a chalky white color, mortar-like in appearance, and of a consistency sometimes soft and sometimes friable. Occasionally it may secrete a milky liquid. The tissue of the disc surrounding the nucleus is healthy. Microscopically, the calcification is seen, partly in the shape of fine grains between the fine fibrous network of the nucleus, partly in the shape of larger blocks, friable in character. The cells of the nucleus are necrosed, and the fibrous tissue is destroyed by calcareous deposit (Schmorl). The chemical constituents encrusted in the nucleus are usually carbonate of lime or phosphate of lime, sometimes uric acid,—as in gout. However, this essentially localized calcification must not be confused with any of the various processes of ossification of the vertebral disc. A satisfactory pathological explanation of the calcification of the nucleus is yet to be offered.

2. *Kyphosis with nuclear retropulsion* (*paraplegia*). *New individualization* (*Galland*).

We intend to individualize a new variety of kyphosis: kyphoses with nuclear retropulsion. Two groups must be distinguished: *A*. The first group, a localized kyphosis, with nuclear retropulsion also localized, consecutive to an anamoly in the primitive somatic vertebral development.

B. The second group, characterized by the following triad: localized kyphosis, nuclear retropulsions, and paraplegia. An anomaly in the development of the cord seems to be the origin of the latter.

First group—(Fig. 11). This group may be illustrated by the following case,—a ten-year-old child with vertebral kyphosis, surprisingly supple, all vertebrae normal, with the exception of one in which a considerable tardiness in ossification was observed (on the level of the future anterior epiphysial zone, antero upper and lower angles). The form of this vertebra resembles the vertebrae in Figure 4. (*Vertèbra en fermoir de Nageotte-Wilbouchevitch.*) If the sketch of the two upper and lower adjacent discs is examined with care, there will be seen on the posterior end of the disc the existence of small notches on the level of the bony adjacent faces, which indicate the position of the nucleus. The vertebrae above and adjacent to the deformed vertebra have bent forward, and the nucleus has been pushed away (much as a cherry stone placed between the thumb and the index would be driven forward) toward the rear of the disc, where, acting as a block, it impedes at this point the straightening out of the kyphos (Fig. 11). We gather that the initial cause in this case can be found in the tardy ossification of the anterior vertebral angles. This lack of ossification has given to the vertebra such form that the adjacent flexion above and below has become a

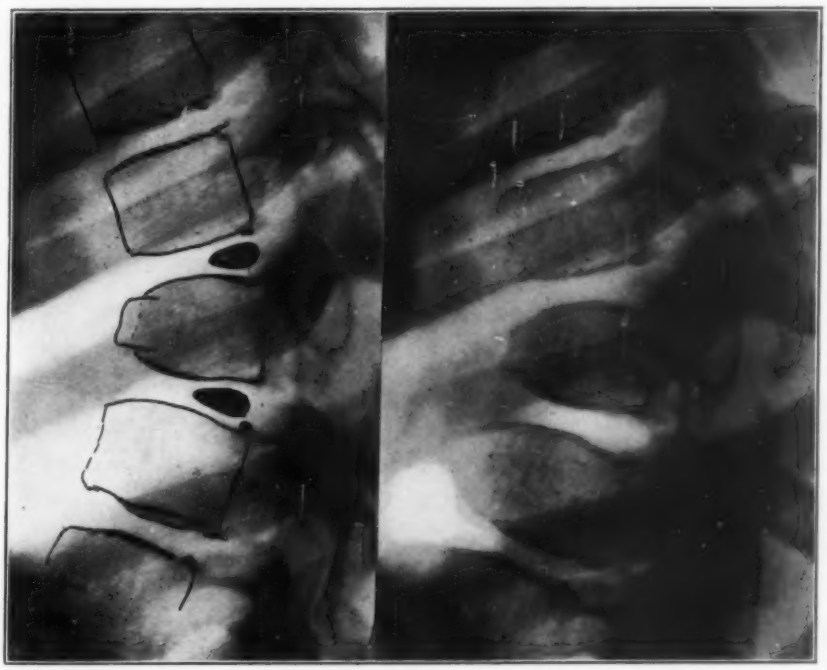

FIG. 11

Kyphos with nuclear retropulsion (Galland), consecutive to an anomaly of anterior development. (Authors' files.)

necessary result. The vertebral distortion is primary, the nuclear retropulsion secondary.

Second group—(Figs. 12 and 13). This group is far more interesting, for it is, in our opinion, a well defined pathological entity. It is characterized by the triad: nuclear retropulsion, localized kyphosis, paraplegia.

First case—A patient, eighteen years old, treated in the well known Parisian clinics, appeared, presenting a most curious and unique case; paraplegia with evidence of sloughing at the level of the sacral and coccygeal roots. He was bent (like the hammer of a revolver) knees to chin, back

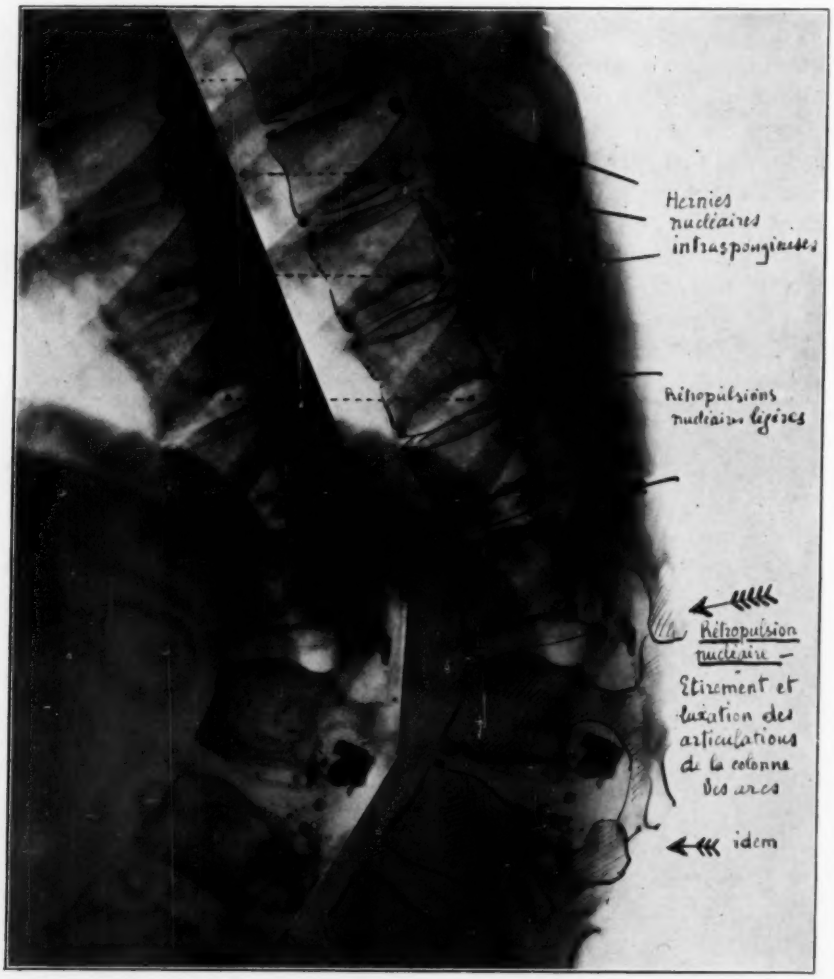

FIG. 12

Syndrome of localized kyphosis and paraplegia (Galland). Observe on the level of the arrest of the intrarachidian lipoidal injection a noticeable intervertebral nuclear retropulsion. (The discs are open from behind, pinched forward, the lesion well localized.) No doubt there is a hernia of the matter from the disc into the vertebral canal with compression of the medullary terminal segment and of the cauda equina.

completely kyphotic. For two years he has been under treatment, undergoing a slow correction, and now is quite straight, but the general health is poor, and he cannot walk. During these two years we have been quite unable to venture any diagnosis (Fig. 12). But now, studying the radiographic plates of this patient, we find two intervertebral discs, cuneiform in shape, at the posterior base (discs of the eleventh and twelfth dorsal vertebrae and discs of the twelfth dorsal and first lumbar vertebrae). The intermediary vertebra has normal contours, but both discs are so pinched forward that the adjacent vertebral surfaces are in contact. Posteriorly the discs are abnormally open, their height being far above that of a normal disc. Both nuclei have, doubtless, been pushed back to the maximum, possibly forming a projection into the vertebral canal. Possibly such a hernia might be the cause of paraplegia. The intraspinal lipiodol is, in fact, so fixed to the level of the affected discs that it can move down to the inferior region only by deviating laterally (as shown in radiographic plates, front view). The plates reveal other curious facts, such as intraspongy hernias at the level of several of the discs. But the more the disc under observation is brought near the two cuneiform discs, the more the nuclear hernia seems posterior, and on the other hand, the more the discs under observation are drawn away from the cuneiform discs, the more central become the nuclear hernias and near the normal seat of the nucleus (Fig. 12). It is seen that all the vertebral bodies are normal in shape. Such an observation, however typical it may be, may suggest that the hernia of the nucleus or of the disc is causing the compression, but does not allow us to build up the pathogenic hypothesis. The following case, however, is essentially different.

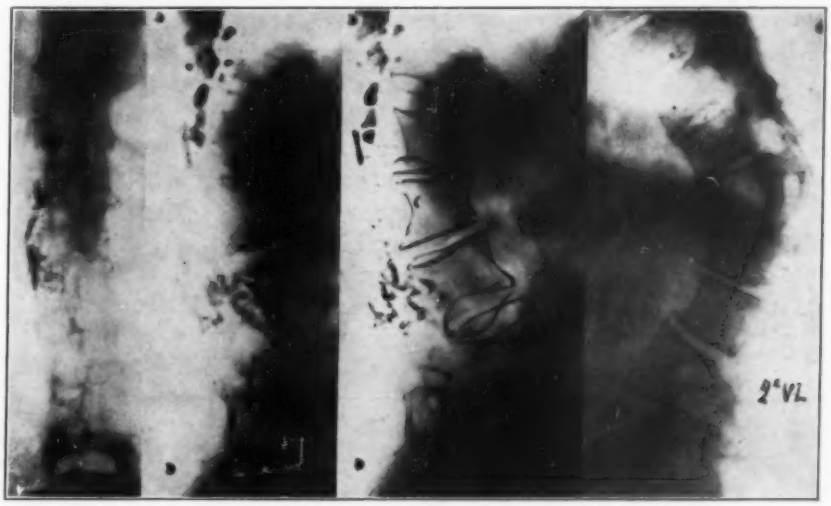

FIG. 13

The same syndrome with paraplegia, but also probable remains of the cord on the posterior surface of the bodies.

Second case—Paraplegia was noticed at about the age of sixteen, progressive, with a dorsal-lumbar kyphosis, the discs on and under the first lumbar vertebra showing the cavities of the nucleus in an extreme posterior position. The intraspinal lipiodol was arrested at the level of the disc of the twelfth dorsal and first lumbar vertebrae. But another peculiarity is observed,—*i.e.*, the existence of light spots at the level of the posterior face of the second and first lumbar, and perhaps twelfth and eleventh dorsal vertebrae (Fig. 13). There being no improvement, the patient was operated upon by another surgeon, who extracted a fungoid mass, nesting on the posterior face of the discs and of the first and second lumbar. This case was not tuberculosis, syphilis, or cancer. The histological examination reported "*meningiome*", but we are inclined to doubt this diagnosis. Could it not rather be some of the tissue of the disc (modified)? It is not known whether tissue of the discs means modified remnants of the primitive cord. (The examination is not of a tumor, but of a kyphos of a very peculiar nature.)

Compare then our own radiographic plates with that of an anatomical specimen by Schmorl (reproduced). This specimen shows plainly remnants of the primitive cord (Fig. 14). These remnants have a similar structure to that of the intervertebral disc (whose nuclei were far too posterior) joined together by remnants of the cord. It seems as if the vertebra were padded with tissue of the disc on its superior, posterior, and inferior faces. The analogy must be noted. Therefore, we take the liberty of proposing the following hypothesis: the kyphoses of the second group (triad: nuclear retropulsion, localized kyphos, paraplegia) may be due to a posterior localization of the primitive cord, together with, at times, anomalies in development. The cord being too far posterior, the nuclei derived from it are situated too far back (first sign). If the ossification is delayed, there may be observed on the posterior face of the vertebrae the existence of remnants of the cord (light spots in radiograph). The kyphos (second sign) is caused by the presence, on the posterior part of the disc, of the nuclei, which make a wedge and, being too far back, cannot play the normal rôle as an axis of rotation. The kyphos is necessarily localized at the level of the maximum backward movement of the cord. Paraplegia (third sign) is caused either by an intraspinal hernia of the disc (first observation) or by the combination, discs and remnants of the cord (second observation). Contrary to that which happens in the first group, the

FIG. 14

Anatomic section of Schmorl's, showing the remains of the cord, in a woman thirty-six years old.

nuclear retropulsion is the initial pathological phenomenon. Such is the opinion which we present for the criticisms of our readers. The future, doubtless, will bring clearer observations.

3. *Rounded discs and absorption of the bony elements.*

We first observed the appearance of the rounded discs in 1920. Radiographically, all of the lumbar vertebrae showed a deformation, the superior and inferior faces depressed (such as the vertebrae of a fish, says Schmorl) in a biconcave, lenticular shape. In contrast the discs were enormous, swollen, balloon-like. The case was one of localized osteomalacia in the lumbar region, puerperal in origin.

In 1926 we observed a child whose vertebrae without exception (sacral included) had such a biconcave, lenticular aspect (Fig. 15), but in this case the phenomenon was far more pronounced than in the former case, so much so that the thick edges of this biconcave lentil (*i.e.*, the peripheral cortex of the vertebra) were no more than one-half of the height of the normal vertebra. All the discs were rounded (Fig. 15). Lasserre published in 1928 a case identical with the above. From that moment we were of the opinion

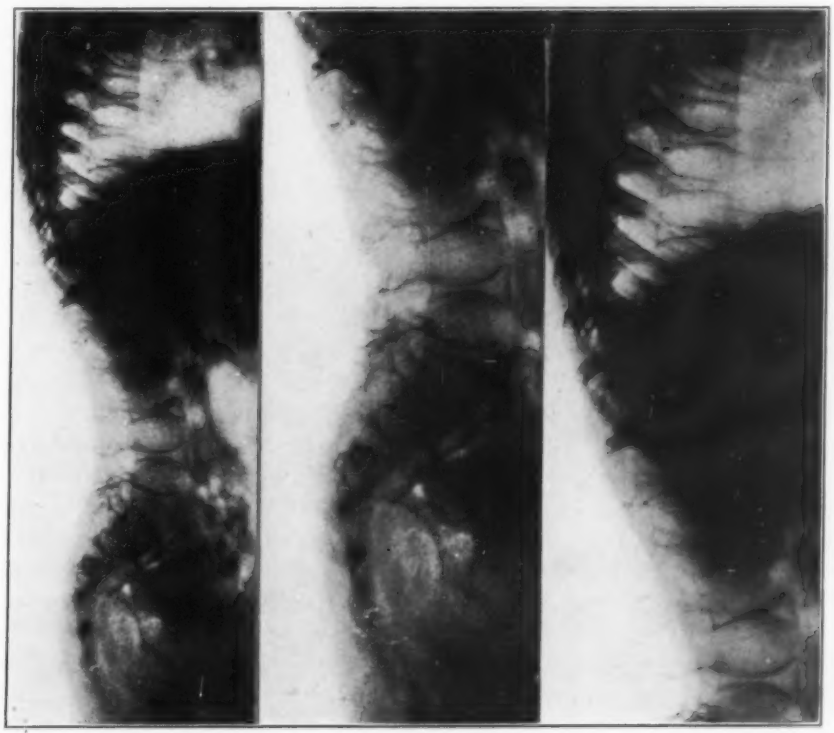

FIG. 15

General osteomalacia. In this case the vertebral absorption was such that the bony counterpressure was weaker than the intervertebral pressure of the nucleus, resulting in the flattening out of the vertebrae into biconcave, lenticular shape, and in spherical intervertebral discs. (Authors' files.)

that it was a case of crushing of the vertebrae (vertebrae with a bony tissue of very low resistance) under the pressure of opposite healthy intervertebral discs, the bony counterpressure being less than the normal pressure of the "*nucleus pulposus*".

Prof. Schmorl gives the same explanation, but draws our attention to cases of localized absorption of bony elements, Paget's disease, vertebral cancer, in which similar deformations may be observed on one surface, or on both surfaces of the same vertebra, followed by a flattening of this latter (Fig. 16). The swelling usually involves the entire disc, but sometimes it is cuneiform or funnel-like. The cartilaginous covering expands and becomes thinner, and may even break at the top of the cuneiform, and a bona fide nuclear hernia appears, the type of which we are about to describe. Figure 16 shows some anatomic specimens of Schmorl's. We have taken the liberty of placing side by side with these one of our most interesting radiographic plates, on which lesions similar to those of the anatomic specimens are shown. Communicated to us by Dr. Andrieu is a case of late syphilis, with Wassermann positive, vertebral pain, and depressed vertebrae and intervertebral surfaces, in which the clinical disturbances disappeared under intensive specific treatment. Similar radiographs may be found in the article by Sicard, Belot, Coste, Gastaud (1925) on vertebral cancer, in which the authors call our attention to localized osteomalacia, cancerous or paracancerous, but do not mention the theory of the hyperpressure of the tissue of the intervertebral disc.

4. *Intraspongy nuclear hernias.*

This is a most curious disease. This affection was individualized by Prof. Schmorl. It is the astonishing history of the normal "*nucleus pulposus*", under pressure, penetrating forcibly into the bony tissue of the vertebra as soon as a crack in the cartilaginous covering appears. Usually there is noticed on the level of the nucleus, or more often on both surfaces of the same disc, little bluish-white centers, often the size of a small green pea. They are formed by some nuclear matter or of fibrous tissue of the disc. A break in the cartilaginous covering is always noticeable at the point of penetration. The nuclear matter penetrates into the openings of the bony vertebral plate; the bony tissue then becomes rarefied. Cartilaginous neoformations may also appear in the center of the nuclear bud. Later the reaction of the vertebral tissue limits the lesion on its periphery by the opposing barrier of condensing osteitis (Fig. 17). It is the stage of radiographic visibility. Such is, in a few words, the pathology of the lesion. We intend to give at a later date a more complete description of the disease. Let us only point out the extraordinary frequency of the lesion; that the break in the cartilage is primary; that, in the adult, there is a preliminary degeneration of the cartilage; that, in the adolescent, there seems to be a peculiar frequency of trouble in development (unfinished enchondral growth, persistency of the non-ossified cartilaginous zone). The volume of such hernias may be considerable, and most varied in shape (like a strawberry, raspberry, or caterpillar). Finally, the following point

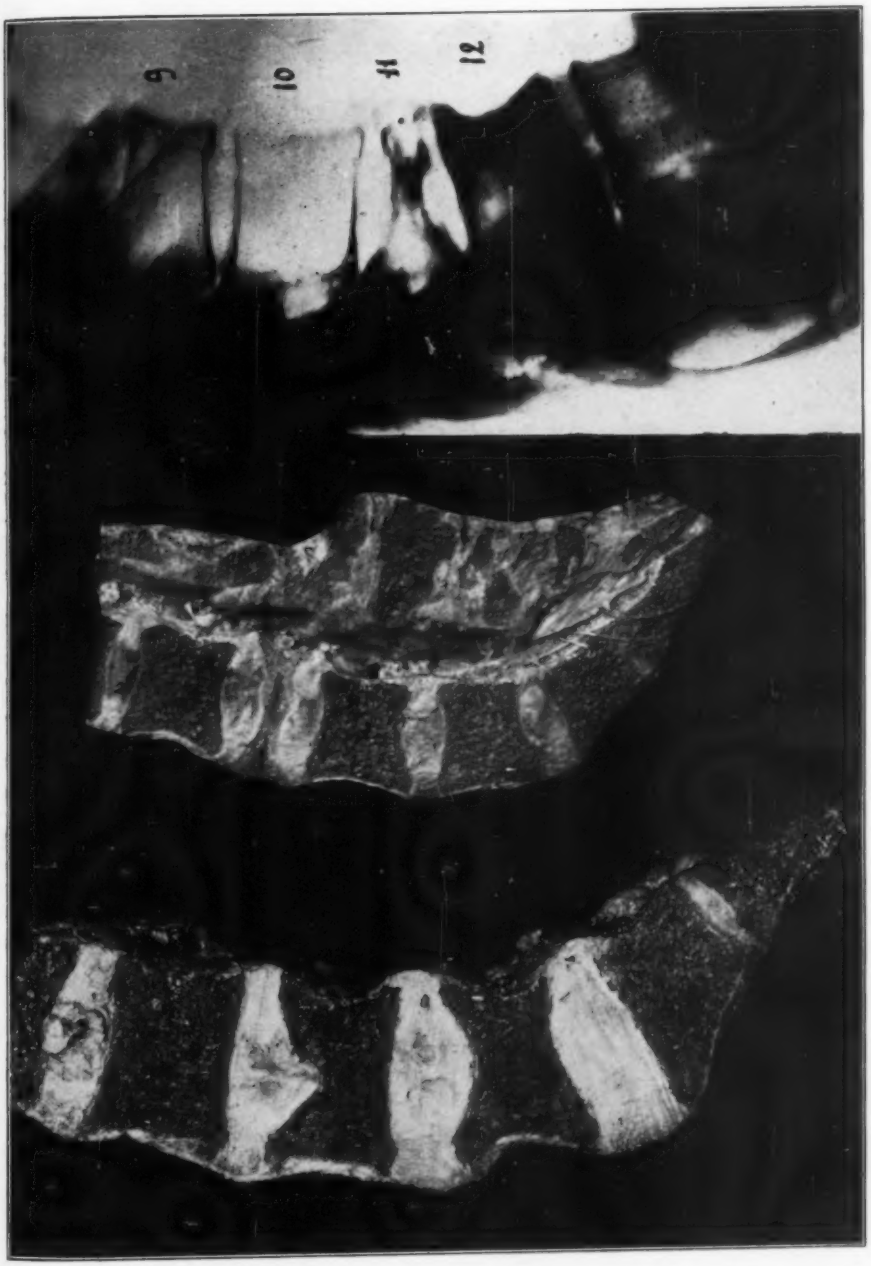

FIG. 16

Localized osteoporoses. Notice the fish-like vertebrae, biconcave lenticular shapes, as well as cuneiform. In the fourth vertebra a hernia even shows on top of the funnel-like shape. In all these cases the bony counterpressure is inferior to the intervertebral pressure of the nucleus. Such facts may be observed in Paget's disease, cancer, syphilis. On the left are two anatomic sections of Paget's disease (Schmorl). On the right is a radiographic plate showing syphilis (Andrieu).

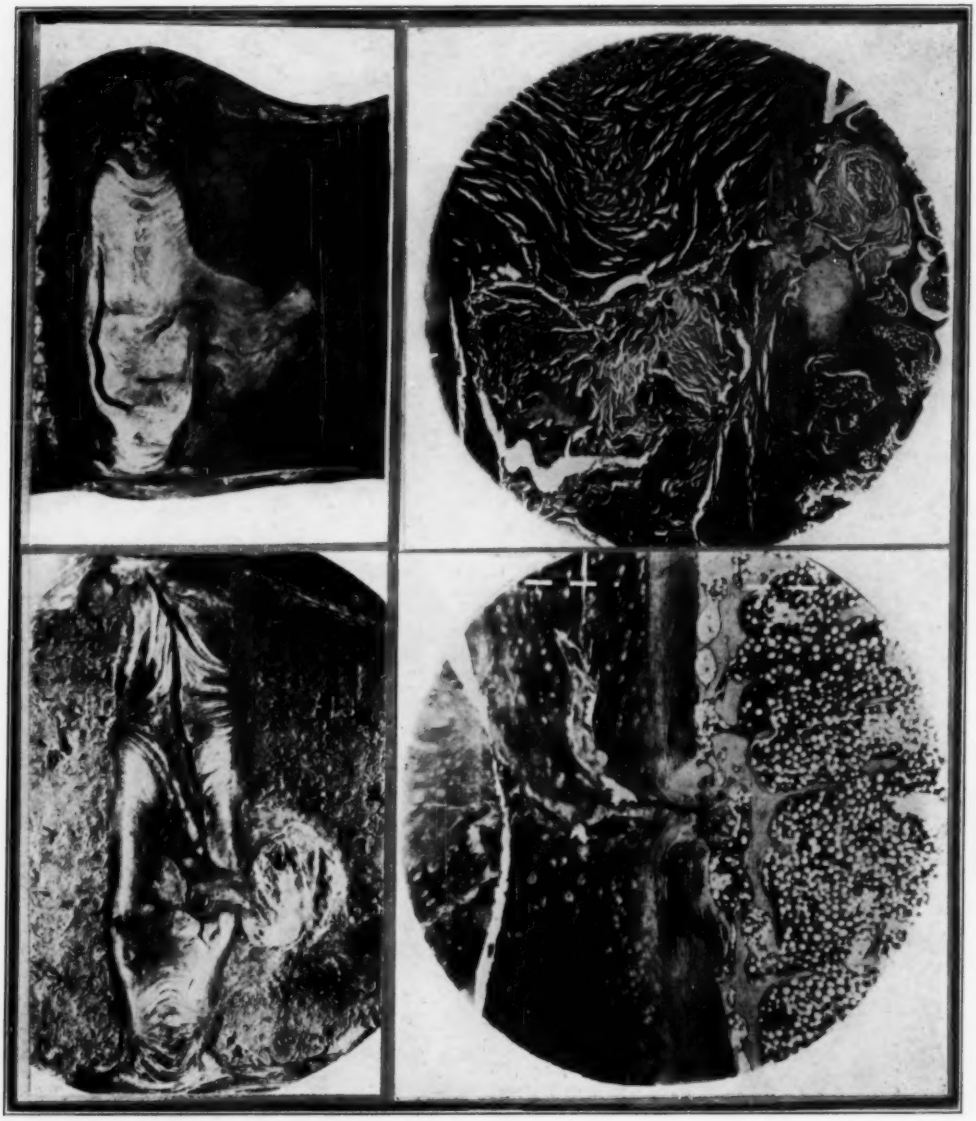

FIG. 17

Intraspongy nuclear hernias—more or less magnified. Notice the ever-present tearing of the cartilage and the

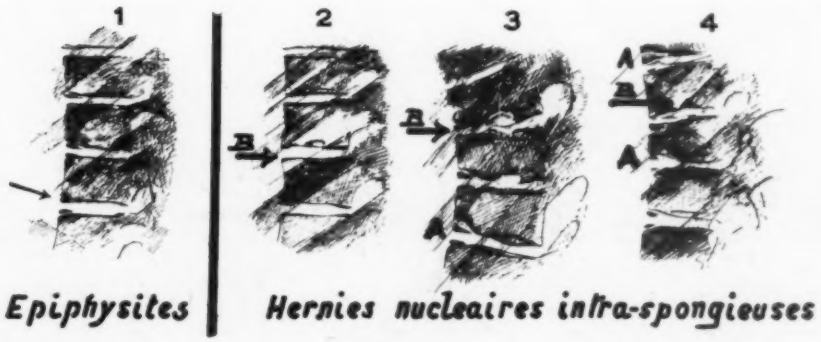

FIG. 18

(From the authors' files.) Radiographically, epiphysitis is characterized by a precocious or slightly hypertrophic ossification of the epiphyseal points (*1*).

Nuclear hernias—always central—have nothing in common with epiphysites. See *B* (*2*, *3*, and *4*), some nuclear hernias; *A* (*3* and *4*), cartilaginous zones, due to an anomaly in development (Schmorl), or trophic affections (authors' observations). Notice that in front of the hernial zones, the vertebrae (*3* and *4*) have taken a cuneiform aspect through compression (law of transmission of forces through non-elastic curved column). Behind the hernial zones, the vertebrae appear normal.

FIG. 17

Intraspongy nuclear hernias—more or less magnified. Notice the ever-present tearing of the cartilage and the

should be emphasized: that the nuclear tissue soon develops into conjunctive tissue, and through a progressive vascularization of the tissue of the disc, the latter loses its elasticity, becoming progressively thin and fibrous.

Such is the anatomical lesion. What are the clinical equivalences?

The frequency of the lesion should be first recognized. Schmorl notices it in thirty-eight per cent. of the columns under observation, and at all ages, most frequently in men (39.9 per cent. against 34.4 per cent. in women). In adolescents, the boys are afflicted more frequently, particularly those addicted to sports. It is also a very frequent lesion in cases of kyphosis, but we have no estimate of the percentage. Such an extreme frequency in nuclear hernias only recognized after autopsies is compatible with the usual absence of clinical manifestation. However, Schmorl, also Schanz, consider that the kyphos is frequently connected with the coexistence of such nuclear hernias. (Schanz is also of much the same opinion regarding the anatomic substratum of its vertebral insufficiency.) Such opinion, as yet, has not been verified, and an exchange of views is now taking place between those two authors, bearing essentially on the function of the traumatism and its importance in such anatomical manifestations.

Let us now consider the problem from our own angle. It is quite evident that most of those lesions are without symptoms; that if we were so long unconscious of their existence, this is due partly to the lack of sufficient anatomical examinations and partly to their usual radiographic invisibility. With further information, they can henceforth be recognized in certain cases. We believe that the painful kyphoses of adolescents, kyphoses with indented discs, diseases called epiphysites are but manifestations of nuclear hernias, hernias reaching the tissue of the disc and arriving

FIG. 19

A few anatomic specimens of nuclear hernias (Schmorl), with a radiogram showing indented discs. Such lesions have nothing in common with epiphysites.

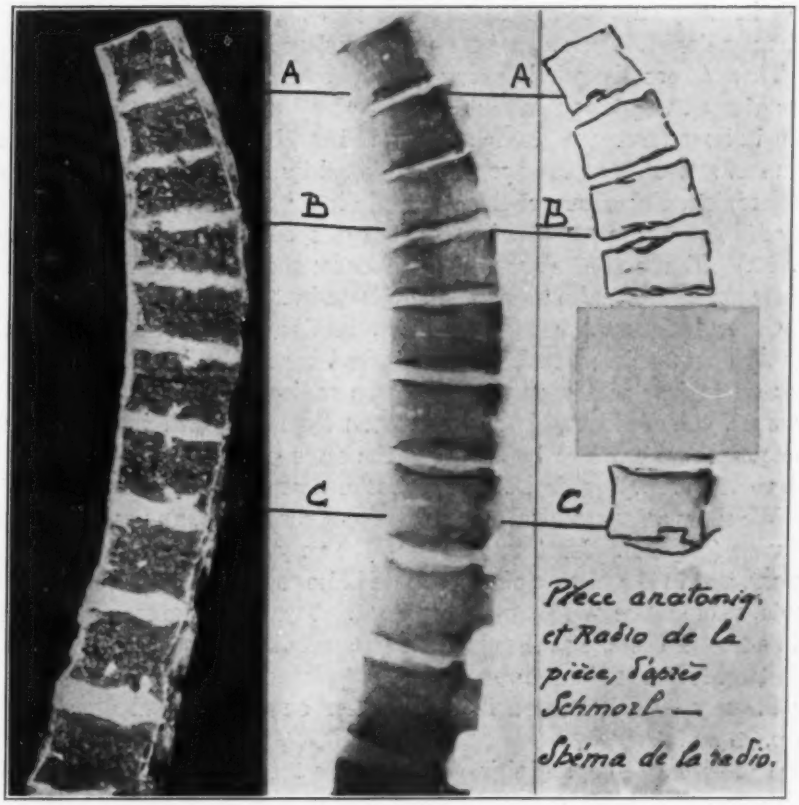

FIG. 20

Anatomic section of nuclear hernia, its x-ray and tracing of x-ray. *A*, similar aspect to that in Fig. 18-*2*. *B*, lesion with indented disc. Such a specimen disproves conclusively any idea of epiphysitis. In fact, Schmorl has never seen any lesion of the epiphyses.

to the stage of conjunctive transformation, even, secondarily, vertebral deformation; and this is what we propose to demonstrate.

We observed recently the case of a young girl eighteen years of age, complaining of pains in the bones, particularly in her legs, and some in the back, with kyphosis. Indefinite diagnosis of the general state, but vertebral insufficiency was evident. The x-ray of the spine was negative in 1926–27; but the patient had been in bed for six months. In 1929, at last, radiographs showed a central nuclear hernia surrounded by a zone of bony sclerosis. This lesion is absolutely typical (Fig. 18–*2*). Some lesions of the same order, hardly perceptible, appeared on other discs. We have not the least doubt, owing to our knowledge of Schmorl's researches, that we were dealing with a nuclear hernia, perhaps consecutive to some trouble of the bones of general nature. However, we saw, at the last Congrès de Chirurgie in October, 1929, in the illustrations shown by Sorrel, a radio-

graph in all points similar to this one and classified as an epiphysitis. Without a doubt, it was a case of central nuclear hernia.

Then comes the whole group of kyphoses of adolescents (14 to 18 years of age), very often painful, difficult of reduction, distinctly more frequent in boys (according to Schmorl) and in which radiographic examination usually shows, at the apex of the dorsal kyphos,—*i.e.*, at the normal dorsal region, three, four, or five pinched discs, very irregular and as if indented. (See accompanying illustrations of specimens and radiographs—Fig. 19.) Figure 18–*3* shows a typical case; there is evidence of central nuclear hernias, but also other smaller disseminated hernias.

Other lesions more complex exist, harder to interpret. However, they also are nuclear hernias. The limited scope of this article does not allow us to interpret now the numerous radiographs in our possession. However, the radiographic aspect of the kyphoses with indented discs (Some cases were shown by Sorrel at the same Congrès) cannot be linked with vertebral epiphysitis, but with intraspongy nuclear hernias (Fig. 18–*4*).

We show an anatomical specimen of nuclear hernia, and radiograph of the same (Fig. 20). In *A* may be seen the very definite picture of a small nuclear, and in *B* a picture of the indented disc corresponding to the nuclear hernia, voluminous and complex in aspect. There is to be seen, moreover, as in all other cases, a pinching of the affected discs (fibrosis); later, cuneiform transformation of the vertebrae. (The law of non-elastic transmission has already been discussed in the chapter on pathological physiology.) (Figs. 18 and 20.)

In reference to epiphysitis, Schmorl, in a total number of 4,000 vertebral columns, has never seen a single case of the lesion of the epiphysis. Consequently, we believe that the name epiphysitis should be limited to painful manifestations during the period of adolescence, sometimes with kyphoses, and in which no deformity of the discs has been observed, but only epiphyseal points prematurely or too largely developed, showing dark, elevated areas, prominent in outline.

We have just described one clinical manifestation, fairly characteristic, of a nuclear hernia (kyphos with indented discs in adolescents). There are certainly many others. We have already observed many similar lesions,—for instance, a nuclear hernia at the summit of a scoliotic curve on the concave side, but it is not possible now to give a more definite opinion. We are glad to be the first to popularize the valuable discovery of Prof. Schmorl and to connect the clinical manifestations with his anatomical discovery, and to undertake to elucidate one of his clinical observations. It is open to all of us to work in this large field of exploration which is offered to us. We believe that by the above exposition, having placed in evidence the very peculiar character of these diseases, there may be seen the relation beween the anatomy and physiology of the nucleus and the affections above described. These are the reasons which have induced us to write this article, a preface to the chapter of the pathology of this intervertebral disc.

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AN EXPERIMENTAL STUDY OF FREE PERIOSTEAL TRANSPLANTS, WRAPPED AROUND TENDON

With a Review of the Literature

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REVIEW OF LITERATURE

Ollier, early in his experiments (1859–67), adapted the method of periosteal transplantation, pedicled or free, in his investigation of the problem of periosteal osteogenesis. The new bone had all the characteristics of normal bone, being covered by periosteum, having an outer compact layer and an inner medulla, containing many of the elements of normal marrow. Ossification did not proceed equally well along the strip, depending on factors such as age of animal, operative technique, adherence of the strip, vascularity of the new locus, functional stimulation given to the transplanted strip, the size of the strip, the type of transplantation (whether autoplastic, homoplastic, or heteroplastic), the immediacy of transplantation, the type of bone from which the transplant was taken (whether long or flat), the integrity of the cambium layer, and the presence of infection. Best osteogenesis was obtained in the rabbit; least in the dog. Periosteum from the juxta-epiphyseal region produced more bone than periosteum from the shaft. Heteroplastic transplantation usually resulted in failure, suppuration, cyst formation, or fibrosis of the periosteal strip supervening; rarely was ossification present. Homoplastic transplantation sometimes produced bone. The new bone could only grow in thickness and not in length, since it had no epiphysis. New formation of bone was usually complete in a month, and there was no further growth. He observed the new bone for three years in one case and believed it could persist in man. There was no cartilage stage through which this bone passed, though a pseudocartilage was observed, which was elastic and hard. Ollier attributed this new bone formation to the activity of the inner cell layer of the periosteum, scraping of which resulted in a lack of ossification. Regeneration of periosteum took place at the point of stripping. He transplanted this regenerated periosteum twice and obtained bone once.

Berutti and Bucholz verified Ollier's experiments. Radzimowsky transplanted bits of periosteum autoplastically into the soft parts of chickens and obtained a new bone, having all the elements of normal bone. Bonome transplanted the periosteum of the femur and of the tibia of the white rat autoplastically into its back muscles, forming new bone. He also transplanted the periosteal strip into the anterior eye chamber and got a lesser ossification. Baetzner buried periosteal pieces, taken from the tibia

of the dog, in the nearby muscle bellies, and obtained no bone in seventy-three experiments. He concluded that permanent bone could not be obtained in grown or growing dogs. Riess, perplexed by Baetzner's negative results, decided to continue his experiments, noting especially the relation between the age of the animal, the presence of the cambium layer, and any resulting ossification. With an intact cambium layer, in young dogs of about seven or eight months, in both free and pedicled transplants, he produced ossification consistently; in dogs over nine months of age, with an absent cambium layer or a fragmented one, ossification was absent. He thereby demonstrated, he said, the conclusive importance of the cambium in bone formation. He noted that there was no relation between the maturity of the new bone and the length of the experiment. There was a definite variation in the amount of bone produced, more massive bone formation being found in free transplants, especially where the two cambium layers came into contact. He did not know how long the new bone would last. In the developing period, he believed the cambium layer to be the innermost layer of periosteum and agreed with Martin that it was to be considered as an introductory stage of bone tissue; in later life, it was not the innermost layer. Thus, he said, vanished the difference between periosteum coming into physiologic function and periosteum covering adult bone. Kolodny stressed the point that most authors do not differentiate between periosteum in the stage of reactive stimulation and periosteum in the latent stage. The periosteum of an adult animal plus a reactive stimulation is equivalent to the periosteum of a young animal. This is quite evident in the repair of a fracture.

Mayer and Wehner, transplanting periosteal pieces from the tibia of dogs into the thigh muscles of the same animal, noted bone formation of a spongy osteoid tissue at fourteen days. Older, new formed bone had marrow tissue. They did not know how long the new bone would last, since they were mainly concerned with the bone-building power of periosteum and did not follow up these experiments. Brown and Brown, Phemister, Davis and Hunnicutt, in somewhat similar experiments, had essentially negative results. McWilliams obtained several successful autoplastic periosteal transplants, though he believed periosteal osteogenesis in soft tissues of slight importance. Jokoi transplanted periosteal strips autoplastically with good neogenesis of bone; homoplastically or heteroplastically, there was very little bone. Tsunoda transplanted periosteal "*stucke*" in very fine form, and obtained positive results in six out of forty cases. Schepelmann conducted a series of experiments to test periosteal osteogenesis in tissues normally containing no bone. He transplanted periosteal strips into the parenchymatous organs,—such as the liver, kidney, brain, spleen, oviduct, ureter, omentum, peritoneum, pancreas, ovaries, bowel, stomach, etc. In the less vascular tissues,—as the oviduct, vas deferens, stomach, bowel—either no bone production or very little took place, a hard fibrous mass usually forming. In the more vascular tissues, as the liver, spleen, brain, ovaries, and less often the kidney,

omentum, and mesentery, better results were obtained. There was a new formation of bone in two months, which advanced the length of the periosteal strip in the following three to four months. He made an histological study of the new bone, and noted that, though at first there was no orderly arrangement of the bone, later, there was a definite tendency towards it, despite the lack of functional stimulation. He also attempted the formation of bone tubes by wrapping periosteum about a glass tube,—the bone tube, if one were to be formed, to be used in the repair of hollow tube defects. Results were unsatisfactory due to patchy ossification of the strip. Cohnheim and Maas injected periosteal flaps into the jugular vein of rabbits, dogs, and chickens, and got bone plaque formation in the pulmonary artery ten to fifteen days later. All the new bone was later resorbed.

Another method of attack was developed by Nakahara and Dilger, and was also used by Sasaki and Pochhammer, all of whom utilized periosteal emulsions to prove periosteal osteogenesis. Nakahara and Dilger cut periosteum into very small bits and emulsified them in salt solution. This periosteal emulsion was then injected either subcutaneously or intramuscularly and a few positive results were obtained. Jokoi, continuing their work, also produced new bone in about half of his autoplastic injections; in homoplastic and heteroplastic injections, successful results were few. When an emulsion of scraped cambium was injected, no new bone was formed. Fibrin injected with the periosteal emulsion increased the tendency to new bone growth, whereas blood diminished it. In all attempts, little pieces of bone, accidently injected, underwent lacunar absorption. Davis and Hunnicutt, using blood clot along with the periosteal emulsion, noticed no new bone formation. Pochhammer saw small bony nodules in fifteen per cent. of his cases, the emulsion being injected intramuscularly. Sasaki, in the treatment of experimental pseudarthroses of the radius, injected an emulsion of finely cut periosteum, producing definite bone bridging between the fragments. On the untreated control side, there was no bridging with persistence of pseudarthrosis. Trinci in experimental pseudarthrosis of the fibula, used free or pedicled periosteal transplants to bridge the defect, the free transplant from the adjacent tibia and the pedicled one from the fibula. In the pedicled type, the cambium layer was placed outside in placing the strip over the fragments, or the pedicle was twisted on its own axis so that the cambium faced normally. He had many positive results. If bone chips were taken with the periosteal flaps, results were usually more successful. He believed the development of an interfragmentary hematoma to be of great importance in stimulating the periosteal cells to osteogenesis. Bone developed after fifty days or more. He advised the clinical use of periosteal grafts in pseudarthroses, though the bone-building quality of the graft was not regular. Since the thickness of the new formed bone was limited, he advised the use of multiple grafts. Phemister, in his experiments, noted that the periosteum, while remaining alive, bridged a bony defect only by fibrous tissue, and not by bone.

Many experimenters have interested themselves in the life force of periosteum—its vita propria—and thus have transplanted periosteum after varying periods of preservation. Grohé, using periosteal flaps obtained from bodies preserved at low temperatures for periods varying from twenty-nine to 100 hours after the death of the animal, got seven successful transplants out of eighteen experiments, when the strip was placed between the muscles of the experimental animal. The flaps preserved their proliferating ability and mitotic divisions were noted as early as three days postoperative, even in strips transplanted 100 hours after death. Nolte produced new bone formation after fifty hours' preservation of the strips. Morpurgo, repeating the experiments of Donati and Solieri, showed that the vita propria of periosteum was still longer. Using young chickens, he noticed that periosteal flaps, preserved 192 hours at a temperature of plus three to six degrees, centigrade, when transplanted to a cock's crest, formed bone; at a temperature of forty to forty-one degrees, centigrade, bone was formed even after 100 hours' preservation, although after seventy-two hours most attempts failed. He also took flaps of periosteum at varying times after death, the body being kept at fifteen degrees, centigrade, and already decayed; and on transplantation, obtained bone, even after 168 hours' preservation. He noticed that temperature had a direct influence on the vita propria of periosteum and that the general decay of the body did not preclude the living quality of its parts. Saltykow obtained results analogous to Morpurgo, transplants being placed in rat tails. Mitosis became active on the fifth day and new bone was present on the eighteenth. Busse noted the independent vitality of periosteum as two to three weeks.

Leriche believes that periosteum is non-osteogenic and says that successful results in transplantation are due to bone particles attached to the periosteum. The technique of stripping is a major point,—the use of a sharp elevator carrying bone chips with the periosteum, the use of the blunt elevator none at all. Therein lies the explanation of many inconsistencies, he argues. He has duplicated the experiments of Ollier and says he can obtain ossification or not at will. "The negative results are due to the death of the fragment of grafted periosteum which does not return to the embryonal state and does not create an ossifiable medium. The successes are due to the fortuitous presence on the deep aspect of the periosteum of particles of bone." The presence of bone is absolutely necessary, in an adult, in order that detached periosteum may form bone. He denies the existence of a special cambium layer and considers the periosteum as a passive ossifiable medium, the periosteo-osseous junction being the site of ossification. Whether or not one agrees with him, his ideas deserve mention. In studying bone formation in the embryo, it is not possible to miss periosteal osteogenesis. Leriche mentions no such studies.

The therapeutic possibilities inherent in the neoformation of bone through periosteal grafting have received moderate attention in the treatment of pseudarthroses and ununited fractures. The experimental work of Sasaki and of Trinci has been reviewed. The early work of

Vulpius, Sohr, and Fröhlich, in this respect, may be mentioned in passing. Mock, more recently, utilizing the method clinically, has treated ununited fractures, pseudarthroses, and delayed union of bones, with excellent success, using both free and pedicled transplants. The ease of technique, the absence of trauma, the large size of the transplant, and the quick reconstructive power of periosteum have appealed to him, especially where there is only a small bony defect. He believes that the fracture site should be completely covered by the transplant. In one case, in which a pedicled flap with its cambium face reversed, was used, an excellent bridge of bone was obtained. Mayer has used this method, though he is careful to carry bone chips along with the transplant. Truehart, using small periosteal pieces obtained from the dog, either chloroformed or killed, caused definite healing in a large bony defect of the clavicle (gun-shot wound). His grafts were the size of flax seed and set three-eights to one-quarter of an inch apart. Some grafts had thin laminae of bone with them.

Rhinoplastic and cranioplastic methods have utilized the method of periosteal grafting with varying success. The earlier surgeons, working in a carbol spray atmosphere—the strips being immersed in a bichlorid of mercury solution—often had no success. Sohr said simple autoplastic periosteal grafts could not be used in the repair of skull defects. Baggio attempted the repair of a skull defect, using a strip one half of periosteum and the other half of periosteum plus bone. There was no bone formation on the periosteal side of the strip. Neuhof notes that adhesions between the periosteum and the brain occur; and says that periosteum is not as smooth, as resistant, or as readily handled as fascia, in closing skull defects. Ollier attempted a rhinoplastic operation, implanting tibial periosteum under the forehead. There was new bone formation at three points, but the strip was removed before the second stage of the operation. Bigelow, using periosteum of the forehead, failed in an attempted reconstruction of the nose. Von Langenbeck used the periosteal flap in a rhinoplasty and closed a palatal defect with periosteum. Grube used a frontal periosteal flap to close a defect in the upper jaw, with definite bone formation in the flap.

Hofmann utilized the periosteal strip as the interposition membrane in the arthroplastic treatment of joint ankylosis. He argued that periosteum is the main factor conditioning the natural form of bone and therefore had a greater advantage over other soft tissues for interposition. The periosteum formed a natural closure to bone and prevented the formation of callus masses, which would vitiate the result of any arthroplastic procedure. In experimental animals, he found that the periosteum functioned as such in its new locus and formed bone, even after transplantation to a wounded surface. Clinically, he operated on four cases, elbow, knee, radio-ulnar joint, and an interphalangeal joint. The results were fair,—the function of the elbow being good, that of the knee poor. He concluded that the transplant is enough to prevent ankylosis. Katzenstein, using a periosteal strip in the operative treatment of flat-foot, described a successful result, the method consisting, in principle, in the approximation of bony

prominences on the inner side of the foot. Neuhof reports the use of periosteum in closing abdominal defects, with poor success. Vulpius, as reported by Steindler, used a periosteal flap to cover the extensor tendons in doing a tenodesis of the wrist. Cramer attempted to arthrodese the ankle by laying a periosteal flap over the anterior surface of the joint.

Schepelmann has perhaps done the most imaginative work with periosteal grafts, though most of it is still impractical and theoretical. Using bands of periosteum wrapped about a glass tube, he was able to construct a bony tube, used for the repair of a tracheal defect. Here, he used individual strips, so that one strip overlapped another. In experimental work, he attempted the formation of bony tubes by wrapping periosteum about glass tubes, these tubes to be used for the repair or replacement of a resected hollow tube, as the oviduct. His results were uncertain, it being difficult to obtain such a bone tube, because of patchy ossification in the strip.

EXPERIMENTAL DATA AND RESULTS

In our own experimental work, we have been swayed by the primary belief that free periosteal grafts can form bone. It was planned to use a free periosteal graft taken from the tibia; to wrap it about the tendon or tendons of the foot and leg, which cross the ankle joint, the cambium face being inwards. We thought that the resultant bridge of bone, if one were to form, might be of use in either extra-articular arthrodesis or tenodesis. The fate of the tendon we could only postulate,—either disappearance by compression or infiltration with bone, or resistance to any such activity. We planned to utilize in the successful production of bone, all those factors of age, functional stimulation, autoplastic and immediate transplantation, adherence of the strip by scarification of the tendon (thereby destroying its synovial sheath), a proper and quick operative technique, and a well preserved cambium. In another series of experiments we planned the formation of bone tubes, by wrapping the periosteal strip about the tendon with its cambium face outwards, using a natural tube (such as the tendon), instead of a foreign body (as the glass tube). These ideas we carried out in the following experiments.

Our technique was in general as follows. The animal (young rabbit, two to six months old) was anaesthetized in a closed chamber with ether, and then placed on its back. Hair was removed with a solution of barium sulphid and the skin painted with picric acid. The experiments were carried out as aseptically as possible. An incision was made the entire length of the anterior surface of the tibia, extending usually from just below the tibial tuberosity to just above the ankle joint. Muscle and fascia overlie the periosteum, which, in the younger animals, is a well developed and a non-adherent membrane. At first, we attempted to secure the periosteum alone; but because of its thinness and its friability, rendering its handling difficult, we took the overlying fascia and muscle along with it. Two longitudinal cuts were made on each side of the tibia,

undercutting the tibia so as to get a greater width of periosteum. A transverse connecting cut was made just below the tuberosity of the tibia. It was then easy to strip back sizable strips of periosteum, without the use of a periosteal elevator, thereby precluding the carrying away of bone chips on the strip. The strips were kept in a gauze sponge soaked in normal saline solution, pending the second stage of the operation. An incision was then made over the prominent tendon of the tibialis anticus (we used the extensor longus digitorum once and the peroneus longus tendon twice), the incision being either separate or continuous with the upper one. The tendon was isolated and lifted out of its bed by passing a hemostat under it. Its surface was scarified gently with an iridectomy knife to promote a greater adherence between it and the overlying graft. In no case was the synovial sheath permitted to remain. The graft was then sutured to the tendon near its insertion, using black silk, and then wound spirally upwards about the tendon, one spiral overlapping another. The tendon was kept moderately taut to prevent its twisting, by the weight of a hemostat attached to the long threads of the first suture. About three or four turns were usually taken with the cambium face either inwards or outwards. The strips averaged one to one and one-quarter inches long and one-eighth to

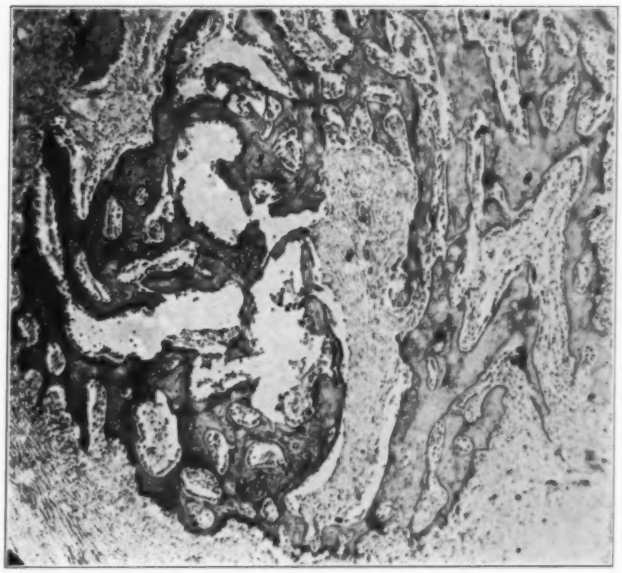

FIG. 1

Rabbit 577, 29 days postoperative. Fiber bone is seen encroaching upon a tendon that is thinned and fibrous.

FIG. 2

Rabbit 577, 3 weeks postoperative x-ray. Lateral roentgenogram showing new bone formation along the course of the tendon of the tibialis anticus.

FIG. 3

Rabbit 541, left side, 57 days postoperative. An unsuccessful result showing fibrosis of the tendon and of the periosteal investment.

three-eighths of an inch wide. The length of the strip would allow investment of the tendon up to the strong transverse ligament of the ankle joint. In no case was the ligament cut. The upper end of the strip was also fastened to the tendon by a black silk suture. The wound was closed with black silk, then painted with picric acid, and sealed with collodion. No dressing nor cast was applied, in order that the transplanted strip might receive continual functional stimulation. The inactivity of the rabbit in the first few days after operation acted as a natural splint. During the transference of the strip we sometimes found it difficult to recognize the cambium side, but its smooth, glistening, gray-pink appearance materially helped us. At varying intervals after operation, the animals were killed and the specimen obtained. As a routine, a small strip of periosteum was always examined for the presence of the cambium layer, in accordance with the experience of Riess. Pre-operative x-rays and x-rays at intervals of two weeks were taken until the termination of the experiment. The specimen removed was examined grossly and microscopically.

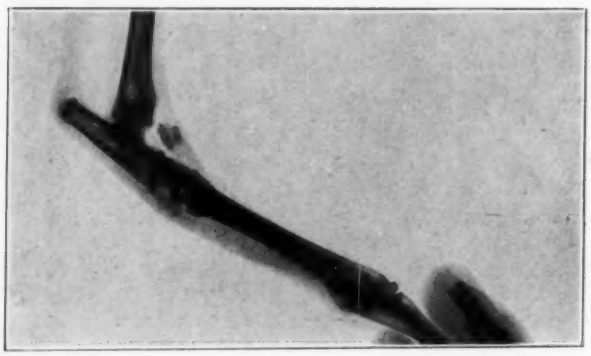

FIG. 4

Rabbit 541, right side, about 3 months postoperative. Lateral roentgenogram showing good bone formation along the course of the tendon of the tibialis anticus.

Our series of thirty-six experiments included twenty-one with the cambium layer placed inside and fifteen with the cambium face outwards, away from the tendon. The experiments lasted from fourteen to about 100 days postoperative. The microscopic determination of the presence of the cambium layer in the

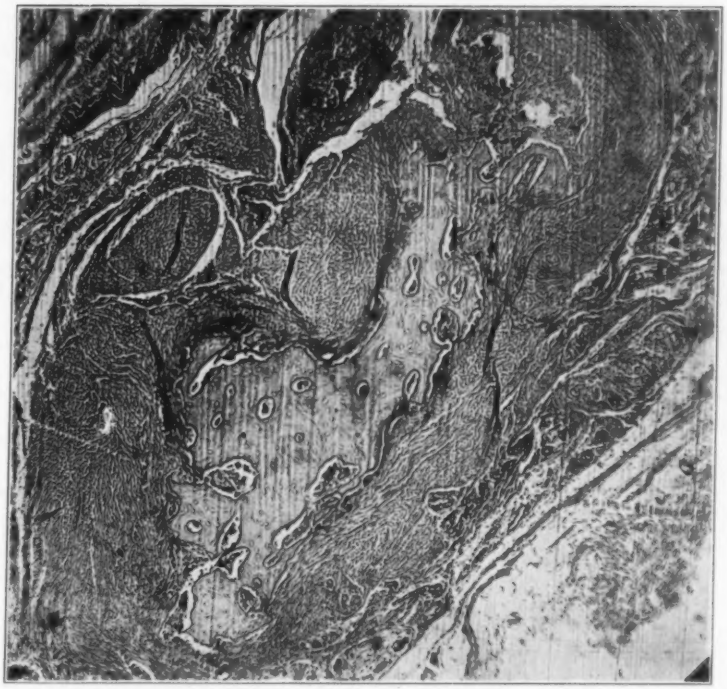

FIG. 5

Rabbit 554, 75 days postoperative. The new bone, here lamellar in structure, is invading the tendon that has undergone fibrotic change.

transplanted periosteal strips was positive in twenty-eight experiments (nineteen with the cambium face inside and nine with it outside), negative in six (one with the cambium face inside and five with it outwards), and undetermined in two (one with the cambium face inwards and the other outwards). We reproved Riess's claims. Where the cambium layer was absent, no bone formation was observed, save in one case; where the cambium layer was present, there was a definite tendency towards the neoformation of bone in nineteen experiments out of twenty-eight. Even with a positive cambium layer, the graft did not always take, depending on many other factors previously noted. New bone was also present in one case where the cambium layer was undetermined,—that one in which the cambium face was inwards.

Infection of varying degree, mild to severe, proved the greatest deterrent of new formation of bone. In six experiments, where definite infection was present, no new bone was seen. In a smaller number (3), where a mild infection was seen, bone was present in an area remote from the infection, and surrounded by a thick layer of fibrous tissue. In one of these cases there was an infection of the newly formed bone. A cheesy plastic exudate was noted twice, binding the soft tissues together; twice a cyst filled with cheesy material and attached to the tendon was seen.

We believe it is not necessary to discuss the two types of experiments separately, in view of the end results. New bone formation was noted in twenty-one experiments. In some cases this new bone may not cast a shadow in the x-ray and can only be revealed microscopically. This bone was first seen about two weeks after the operation, and was a typical, periosteally formed fiber bone. In a few cases, endochondral new bone formation was present, evidently derived from the transplanted periosteum. Since it has been believed that bone formed from transplanted periosteum does not pass through a cartilage stage, this may not be always true. It is unnecessary to enter into a detailed story of the structure of the new bone, since Jaffe has done it so well in his article on "The Structure of Bone". It is enough to say that the new bone matures in direct proportion to its age, the fiber bone becoming definitely lamellar. The marrow first observed is a connective-tissue marrow, and only in older, newly formed bone, does it become hematopoietic. In a few experiments, where we attempted to get bone chips along with the periosteal strip, no increased bone formation was observed.

The new bone was well seen in the lateral roentgenograms, usually first at two weeks after operation. Bone formation did not proceed uniformly along the strip in most cases, though in four a good spiral of bone

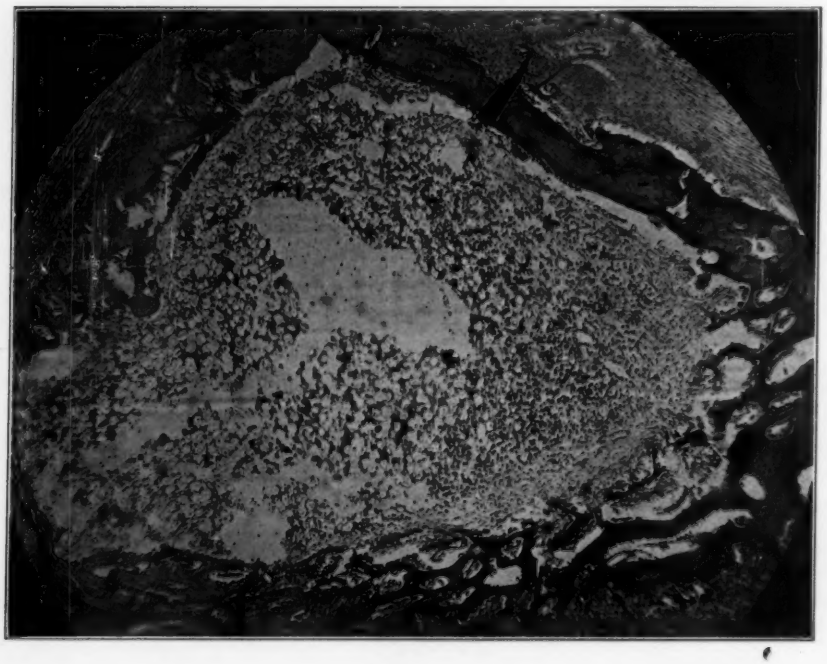

FIG. 6

Rabbit 561, 49 days postoperative. There is new formation of bone in the form of a tube. The marrow is hematopoietic. (Microphotograph reduced by one-fifth.)

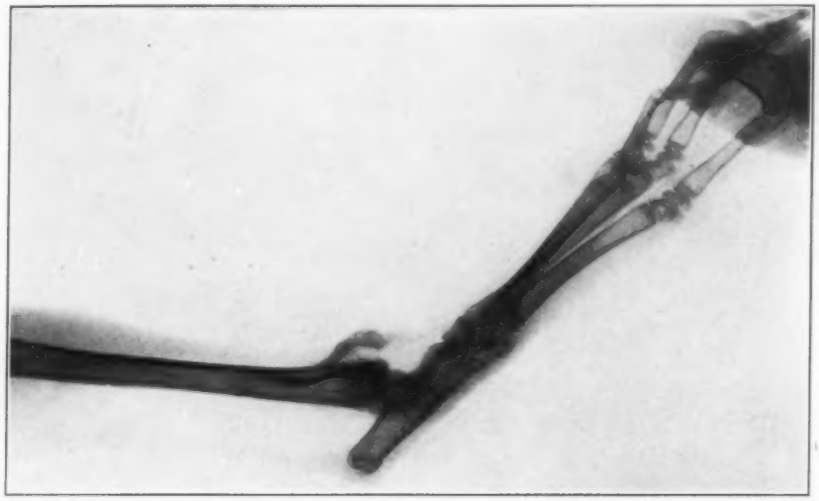

FIG. 7

Rabbit 561, 49 days postoperative. Lateral roentgenogram.

was observed, encircling the tendon. The tendon of the tibialis anticus casts a very definite shadow on the plate, which at first we tended to confuse with a light ossification. Certain points seemed to be the site of predilection for ossification,—near the ankle joint, near the insertion of the tendon, and near its center. The new bone formed near the ankle was large and often formed with the new bone derived from the remaining curled piece of periosteum over the tibia, a large exostosis partially bridging the ankle. The maximum average length of new bone that could possibly be formed with spiral winding of the strip was about ten to fourteen millimeters. In eighteen experiments, no new bone was seen in the x-ray; in five, the new bone averaged one to three millimeters long; in four, from seven to thirteen millimeters; and in the remaining nine experiments, from three to six millimeters long. The thickness of the new bone varied from one millimeter to even twice the width of the tibia. In a single specimen there might be several points of bone formation. In some cases there was a large heaping up of bone. In older experiments there was noted in the x-ray a definite tendency towards an outer compact border and an inner less dense medulla. In a few cases resorption of bone, as indicated by the disappearance of the shadow, was seen,—more often when ossification was light. It is possible that all of the new bone may ultimately be reabsorbed, the length of our experiments not enabling us to decide this point. The tibia, at the site of stripping, sometimes showed a feathery increase in density in the soft tissues, which usually disappeared in three to four weeks. In one case, the stripping of the periosteum was followed by an osteomyelitis of the tibia, the roentgenogram strongly resembling that of an osteogenic sarcoma. The amount of new bone seen by x-ray and at the time of removal of the specimen usually corresponded.

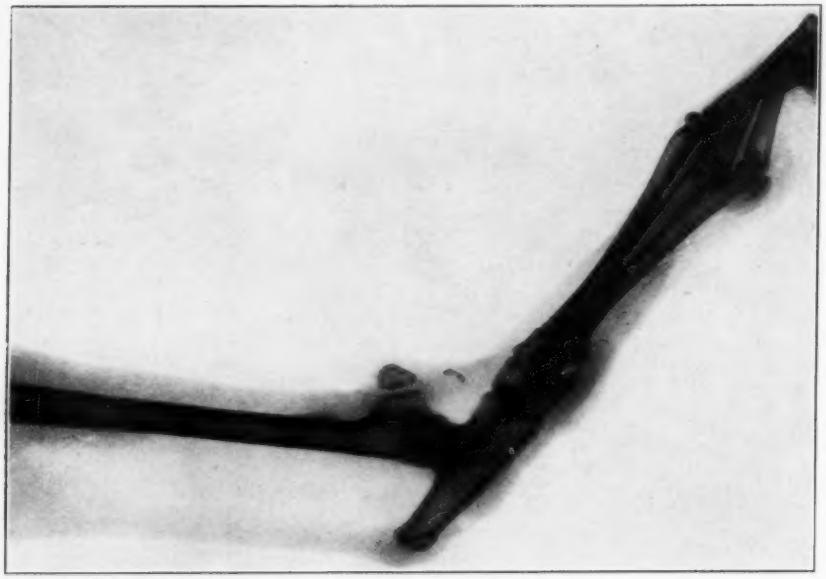

FIG. 8

Rabbit 537, about 100 days postoperative. Notice the bony outgrowth on the lower end of the tibia, derived from the remaining curled-up piece of stripped periosteum.

The tendon specimen removed showed the tendon surrounded by a fibrous investment, in which bony nodules along the course of the tendon were often felt. The normal tendon was seen entering and leaving the cuff-like investment. The tendon usually was very adherent to its investment, though, in a few cases, attachment was loose and the tendon slipped out. Where this happened, no new bone formation was observed usually. The tendon appeared normal. The new bone felt along the course of the tendon was sometimes in the form of a spiral, sometimes a nodule, or a small nubbin of bone, or a large outgrowth. Where no bone was present, only the fibrous coat was noted, to which the tendon adhered. In life and in death, the mobility of the ankle joint was normal, since the transplant was only carried as far as the transverse ligament, determined by the length of the strip. However, it was felt that had the strip crossed the ankle, the resulting bridge of bone might have acted as a mechanical block, especially since most new bone formation was observed near the ankle joint. There was usually complete reformation of the periosteum over the tibia, though we did not pay much attention to this point.

The microscopic picture cleared up the fate of the tendon, whether the cambium face was inwards or not. Whether, by disturbance of circulation due to the destruction of the mesotendon, or by compression of the tendon by the newly formed bone, the tendon underwent a fibrous change,—a gradual replacement of tendon tissue by fibrous tissue. The fibrous tissue in turn was infiltrated by the coarse bony trabeculae of the

new bone, till finally only a central core of fibrous tissue containing a few blood vessels was seen. The tendon, sometimes, showed a foreign-body reaction with the production of giant cells, usually at the site of a stitch. Where infection was present, an infectious tenonitis was observed. The tendon fibers early became swollen, with later fragmentation and loss of staining power. The periosteum was also destroyed by the infection, with final replacement by fibrous tissue. In some specimens, especially with the cambium face outwards, at an area well away from the major infection, walled off by fibrous tissue and under the skin, small plaques of bone were seen. In only one case were we able to grow a continuous tube of bone, with the cambium face placed inwards. Where no infection was present and no bone was formed, the tendon was hyalinized and the periosteum fibrotic.

We doubt very much the usefulness of periosteal grafting in tenodesing and extra-articular arthrodesing operations, the irregularity of ossification militating against such a procedure. The therapeutic formation of bone tubes is still too uncertain to warrant practical use.

We are happy to acknowledge our great indebtedness to Dr. Henry Jaffe, who was always ready with his assistance both in the course of the experiments and especially in the histologic work and to Dr. Leo Mayer to whom we presented our problem and who arranged for its carrying out. He, too, has helped us much with his advice. We also wish to thank Dr. M. Langsam and Mr. Bruno Riemer for their ready help all through the course of this work.

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*The above is a fairly complete index of the literature on periosteal grafts. Not all have been mentioned in our review of the literature. Some articles we could not obtain in the library of the Academy of Medicine, New York City.

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DOUBLE ISOLATED COMPRESSION FRACTURE OF THE SPINE*

BY CHESTER C. SCHNEIDER, M.D., MILWAUKEE, WISCONSIN

Although fracture of two or more adjacent vertebral bodies is more or less commonly seen, fracture of several isolated vertebrae separated by one or more intervening uninjured vertebrae is a much rarer clinical entity. The purpose of this paper is to report three cases of double isolated compression fracture of the spine and emphasize the occurrence of this condition as a clinical entity.

CASE 1. A physician, aged fifty-three and weighing 260 pounds, was thrown from his car into a ditch when the car was struck from the side by a large, high-powered sedan going at a rapid speed. Although the exact character of his fall could not be determined, there was reason to believe that he landed on his head, and the after-coming body and legs forced the spine into acute flexion. In addition to injuries to the spine, he sustained a concussion of the brain and a Colles' fracture of the right wrist. He regained consciousness in about three hours in a hospital where his wrist was set and minor wounds

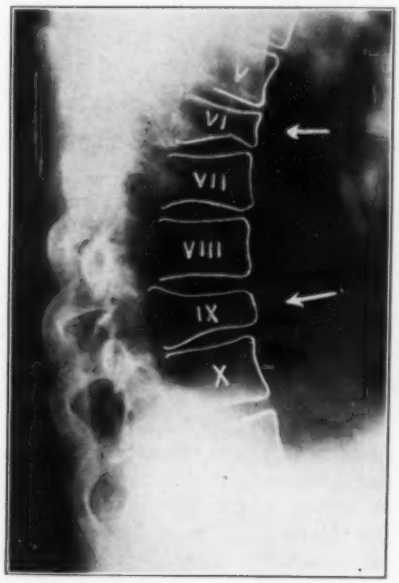

FIG. 1

Lateral view of dorsal spine (Case 1), showing typical compression fractures of the sixth and ninth dorsal vertebrae.

FIG. 2

Anteroposterior view of spine (Case 1), showing compression fractures of sixth and ninth dorsal vertebrae. Injured segments are characteristically flattened and widened and spine is deflected slightly to left.

*Read before the Milwaukee Academy of Medicine, March 11, 1930.

FIG. 3

Lateral view of dorsal spine (Case 2), showing typical compression fractures of fifth and tenth dorsal vertebrae with rather marked kyphos at level of fifth.

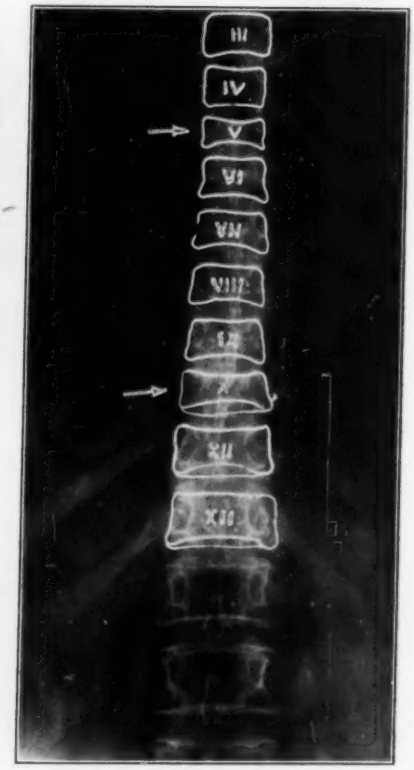

FIG. 4

Anteroposterior view of dorsal spine (Case 2), showing compression fracture of fifth and tenth dorsal vertebrae. Bodies of involved bones are compressed and broadened.

to the skin dressed. No special studies were made of the spine until about three months later when persistent pain in the mid-dorsal region radiating around the chest, of such intensity as to prevent him from sleeping at night, caused him to seek further consultation. X-ray studies at this time, taken at the Evangelical Deaconess Hospital, Milwaukee, revealed typical compression fractures of the sixth and ninth dorsal vertebrae with rather marked lipping of the upper and lower anterior margins of the intervening bones. The anterior margins of the crushed vertebrae were compressed to almost one-half of the normal depth in the lateral views; while in the anteroposterior views, the bones were distinctly flatter and broader than normal (Figs. 1 and 2). This evidence led to the conclusion that this was an undoubted case of double isolated compression fracture of the sixth and ninth dorsal vertebrae, the history of injury, symptomatology, roentgenology, and clinical course being typical.

CASE 2. An elderly woman of sixty-eight, weighing approximately 130 pounds, had her head and chest hyperflexed on her abdomen, in the rear compartment of a sedan automobile when the latter turned over in a collision with another car. She experienced immediate pain and disability in the spine but no evidence of cord pressure. X-rays of the spine taken at the St. Lukes' Hospital, Milwaukee, revealed compression fractures of the fifth and tenth dorsal vertebrae with normal intervening bones. Figures 3 and 4,

showing lateral and anteroposterior views of the spine, reveal typical compression fractures of these vertebrae with marked forward angulation at the level of the fifth.

CASE 3. A man of sixty, weighing approximately 140 pounds, was struck on the head by a large steel tripod several hundred pounds in weight. His head and spine were bent forward at the moment of the impact and were forced into acute hyperflexion by the thrust of the falling object. The patient did not lose consciousness, but says he "had the wind knocked out of him". He felt a severe pain in the mid and lower dorsal spine with radiating pains around the chest and abdomen, but suffered no neuromotor disturbance in any part of the body. Roentgenograms taken at the Evangelical Deaconess Hospital, Milwaukee, revealed compression fractures of the sixth, seventh, and eleventh dorsal vertebrae with moderate forward tilting of the spine in the involved regions (Figs. 5 and 6). The intervening vertebrae were entirely negative for evidence of injury. Reduction of the deformity by the application of a cast with the torso in hyperextension completely corrected the deformity and produced an immediate remission of symptoms.

The first two of these cases were the result of automobile accidents in which the occupant was either thrown out of the car onto his shoulders

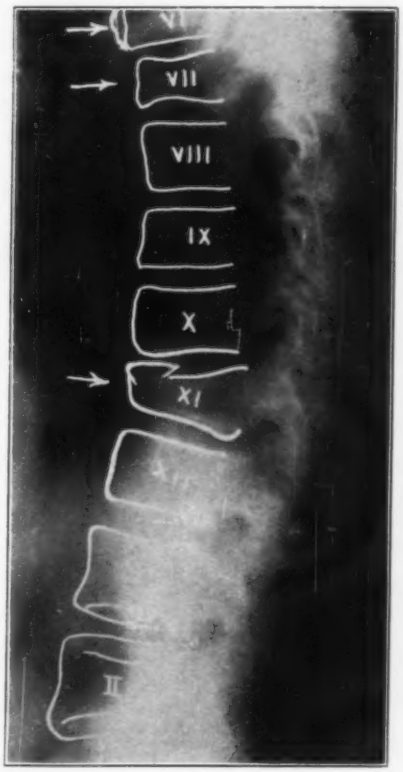

FIG. 5

Lateral view of dorsal spine (Case 3), showing compression fractures of sixth, seventh and eleventh dorsal vertebrae. Sixth and seventh segments are only moderately compressed, while the eleventh is compressed and fragmented. There is a moderate increase of dorsal kyphosis in the injured areas.

FIG. 6

Anteroposterior view of dorsal spine (Case 3). Injury to sixth and seventh vertebrae not clearly evident in this view, but that to eleventh more definite.

or thrown over in the rear compartment of a sedan. The mechanism of production is that of jack-knifing or hyperflexion of the spine, which is generally recognized as the most common cause of all spinal fractures. In the instances where double fracture occurs, the force must be greater or longer sustained so that the crushing effect is not dissipated or exhausted with the compression of one vertebral body, but continues on to the second. This mechanism is not infrequently observed in injuries of long bones where two or more individual fractures occur along the shaft of a single bone, widely separated from each other. Moreover, it is evident, from statistical studies, that the transition from the dorsal to the lumbar spine is the least adapted to yielding to indirect violence. In instances where one compressed vertebra is in this region and the other above or below it, it is conceivable that the primary crushing force was directed to the mid-dorsal or mid-lumbar region and extended secondarily to the dorsolumbar junction. Thus, in the third case in this series, where the patient retained consciousness throughout the period of injury, it was evident that the primary levering force was directed to the mid-dorsal region, causing compression injuries to the sixth and seventh dorsal vertebrae, but the continuance of the hyperflexing force caused the persisting leverage to localize at the dorsolumbar region of least resistance, producing an additional compression of the eleventh dorsal vertebra. This is apparently the mechanism of these fractures and has been present in all the cases observed or reviewed by the author.

To date twelve cases of double compression fracture have been reported in the literature, eleven of which are reviewed by Guleke and one by Eikenbary.

A perusal of these case summaries shows that isolated compression fracture of two or more vertebrae with from one to eight normal intervening vertebrae occurs. Most frequently three vertebrae intervene. A predilected involvement of the eleventh dorsal to second lumbar can be recognized in the material thus far observed, although this is not the case in all instances; it was evident in nine of the fourteen cases reported to date. Whereas the sites of fracture are generally distributed in such a manner that they involve the cervical and dorsal or dorsal and lumbar portions of the spinal column, all of the fractures are occasionally situated within one section of the spine.

The important deduction in connection with these fractures is that they do occur in probably greater frequency than is evident from this statistical study but are generally overlooked. It is very likely that even in those instances where one compression injury is discovered, a second or even a third may be overlooked because the observer is satisfied with his single finding and does not carry his investigation or observation beyond this point.

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SYPHILIS OF BONE

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In 1909 I published some experiences illustrating the relationship of bone matrix and general disease. I referred especially to malaria, chronic cardiovascular disease, nephritis, and infectious diseases. I have since had the opportunity of examining the ribs and other bones from more than 700 autopsies. In 100 of these there was a history of lues or evidence of syphilis at autopsy. Many of the cases were proven luetic by the Wassermann test.

In my earlier work on ribs I noticed certain changes in the bone substance not corresponding to any disease of bone with which I was familiar. Typhoid fever and chronic pleurisy were the only diseases that modified the ribs similarly, but not exactly in this way. After looking up the protocols and histories I learned that these odd appearances were in autopsies of syphilitics.

In typhoid there is often seen a layer of osteoblasts bordering the trabeculae. Frequently new bone lamellae are laid down in small numbers. The marrow, however, is that of an acute infection and contains large phagocytic cells.

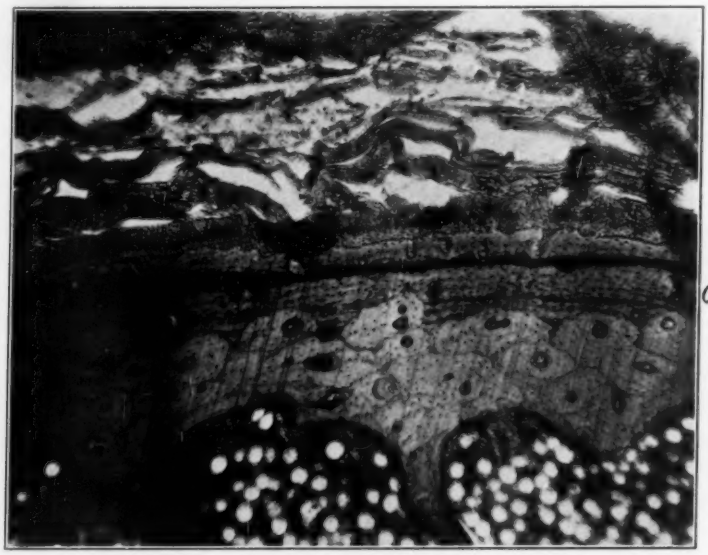

FIG. 1

a. New bone containing haversian canals. The dark line is calcium. (The entire rib is symmetrically rimmed with layers of new bone.)

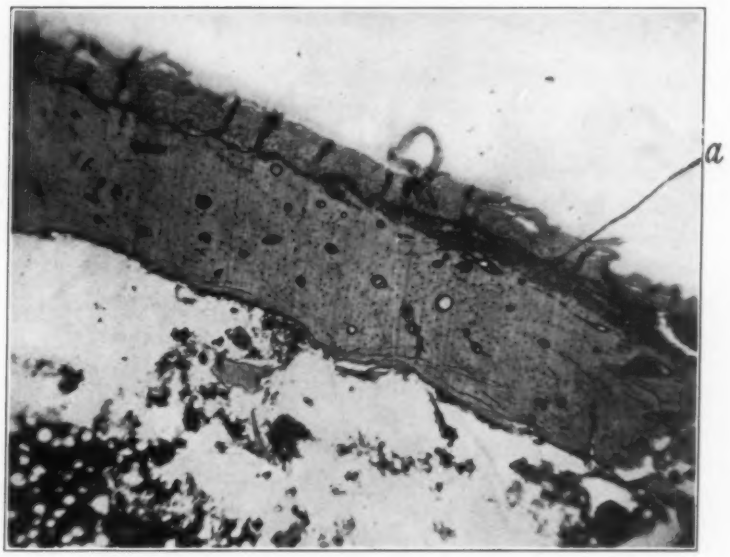

FIG. 2

a. Osteophytic nodules. (Like nodules were seen, irregularly placed, around the entire circumference of the rib.)

In pleurisy with adhesions, the new bone is like that seen in syphilis, but is always limited to the pleural side of the rib. The adherent pleura is present.

PATHOLOGY OF 100 SYPHILITIC RIBS

The ribs of syphilitics invariably demonstrate new bone formation. The periosteum is cellular. The new bone is usually seen in new strata at the periosteum. Frequently the strata are interrupted by irregular zones of branching layers which contain haversian canals. Necrotic areas are often found. The trabeculae (cancelli) frequently give evidence of new bone layers. Sometimes osteoblasts border the new strata. The new formation often rims the entire rib. Nodules of new bone (osteophytes) are seen in some ribs at irregular intervals at the periosteum. In old long continued cases of syphilis with a cardiovascular history, the bone resembles Paget's osteitis deformans (See Cone: The Pathology of Osteitis Deformans). The marrow does not invariably show serious involvement but often appears hyperplastic.

The only pathognomonic findings are gummata. The vessels are frequently fibrosed. There is no evidence of lacunar absorption in the less pronounced cases. There is no round-cell infiltration in the new periosteal bone strata.

I have briefly outlined what I have seen in 100 cases out of 700 autopsies. For the common changes in bone due to syphilis, one should read the excellent article by Gaenslen and Thalhimer (See Bibliography).

The inference must be made that a poison is present which stimulates the connective-tissue substance (matrix) to hyperplasia. I judge that a degeneration with circulatory modification, such as I wrote about in Paget's disease, is responsible for calcium increase locally. With oedema, congestion, calcium, and modified connective tissue, we have the elements which Leriche and Policard assert are prerequisites for bone formation.

Attention is called again to the oedema and alternating active and passive congestion referred to by me in all my writings on bone pathology. When familiar with the pathology of the rib described above, one can without fail diagnose syphilis from the rib alone.

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THE STRUCTURE AND FUNCTION OF ARTICULAR SYNOVIAL MEMBRANES*

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I. STRUCTURE

This investigation was undertaken at the suggestion of Dr. Meyer because of the uncertainty and disagreement that still exist regarding the structure of synovial membranes. Gould's Dictionary of Medicine defines the synovial membrane as "a membrane covering the articular extremities of bones and the inner surface of ligaments entering into the formation of a joint", and various authors describe the inner lining as an "intim", an "epithelium", an "endothelium", a "mesothelium", a "mesothelial-endothelium", or a "mesothelioid" layer of cells. At the present time there is no agreement regarding the anatomy and physiology of the synovial membrane, in spite of many investigations on the subject. A survey of the literature hence seems justified, although much of it is only of historical interest.

Historical Introduction

According to Hyrtl (1880) "synovia" (synophia) was the name Theophrastus Paracelsus (1493–1541) gave to the fluid present in diarthrodial joints on account of its resemblance to the white of egg. The name "synovial membrane" was applied about two hundred years later by Bonn (1763) to the inner lining of joint cavities, previous to which time the structure was included in the "capsular ligaments" of the joints.

The large fatty appendages of the "capsular ligaments" commonly spoken of as villi, which should not be confused with microscopic synovial villi, were seen by Vesalius and Estienne, but were first described by Cowper and particularly by Clopton Havers (1691) under the name of "mucilaginous glands". Havers regarded them as secretory glands of the synovia, a view which was held by Winslow (1732) and other anatomists of his time, who named them "Haversian glands", a term still current in texts on surgical anatomy. Weitbrecht (1742) called these fatty bodies "adiposo-glandulosae".

Disdier (1761) wrote, "*Les glandes muscilagineuses ou synoviales sont des petits corps glanduleux plus ou moins gros en forme de grains considerablement ranges situés dans différents points des articulations pour être exposés à leur frottement, dont l'usage est de séparer de la masse du sang une humeur propre à lubrifier des articulations et à les entretenir dans leur jeu naturel*",

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a view which was supported by Cheselden (1795) who said, "Every cartilage for a sliding motion is furnished with small glands, which separate a mucilaginous matter for the lubrication of the ends of bones . . .".

The rôle of the haversian glands as secretory organs was questioned by Monro (1788) and Bichat (1799). The latter concluded that these structures were merely fatty appendages and were not concerned in the secretion of synovia, because synovia is secreted where no such bodies exist—as in mucous sheaths of tendons and bursae mucosae—; and secondly, because they are ductless and are not glandular in nature; and lastly, because they possess all the characteristics of fat. The function of the haversian glands as agents of synovial secretion was thus entirely disproved, although some later writers, among them Rainey (1846), still believed that "the proper office of this structure is to secrete synovia". The haversian glands, then, came to be known as "haversian fringes", a much more appropriate term. However, as late as 1923, Fisher stated that, "The membrane surrounding certain fatty processes projecting into joints, such as in the infrapatellar pad of fat, is so richly furnished with these secreting cells that the name 'synovial glands', originally given them by Clopton Havers, seems amply justified".

The continuity of the synovial membrane over the surface of the articular cartilages was first described by William Hunter in 1743 who spoke of a "continuation of that fine smooth membrane that lines the capsular ligament; . . . where it covers the cartilage it coheres to it so closely, that it is not to be traced in the recent subject without great care and delicacy". From this description it is plain that every joint is invested with a membrane, which forms a complete bag, and gives a covering to everything within the articulation, in the same manner as the peritoneum invests not only the parietes, but the contents of the abdomen.

Bichat (1799) emphasized the relation of the synovial to the serous membranes, and considered them as closed sacs completely covering the articular cartilages. In the "new edition" of his *Traité des Membranes*, edited by Husson (1816), he wrote, "*On doit donc concevoir toute membrane synoviale comme une poche non ouverte, déployée sur les organes de l'articulation, sur les cartilages diarthroidiaux . . .*" and again—"*Je crois, que, malgré l'adhérence de la synoviale sur divers points, elle doit être considérée d'une manière exactement analogue à celle des membranes séreuses, c'est-à-dire comme une véritable poche sans ouverture, partout continue et déployée sur tous les organes de l'articulation*".

Villerné (1821) considered the synovial membranes as "*sacs membraneux sans ouverture*", formed of cellular tissue, and Todd in 1835 wrote, "The articular synovial membranes (by the older anatomists called, and confounded with, the capsular ligaments), like all others, possess in common with serous membranes the form of a sac shut in at all points; they line the whole interior of the joints, and secrete from their internal surface a peculiar fluid, obviously destined for the lubrication of the articular surfaces". Although most of the anatomists of that time were of the opinion that the

synovial membrane was continued over the articular cartilages this was "called in question by Cruveilhier, Gordon, Magendie, Bladin, and more recently by Grendin and Velpeau" (Todd). Velpeau (1837) stated, "*Si les toiles synoviales n'existent à l'état de membranes isolables ni sur les cartilages, ni sur la partie serrée des ligaments, il est du moins incontestable qu'elles se continuent sans ligne de demarcation appréciable avec ce qu'on pourrait appeler surfaces synoviales des articulations*".

After very careful dissection, Henle (1838) maintained that the epithelium of the inner layer of the synovial capsule was continued over the cartilage but was separated from it by a very thin layer of cellular tissue. He wrote, "*Die Bänder und Knorpel, welche die Höhle eines Gelenks durchsetzen, erhalten einen Überzug vom Epithelium, dasselbe setzt sich in dünnerer Lage auf die Gelenkflächen der Knorpel fort auf denen es von den Knorpelkörperchen durch eine dünne Lage Zellgewebe geschieden ist*".

Toynbee (1841) held that "the synovial membrane is extended over the surface of the articular cartilage" but Cruveilhier (1843) stated, "*Sans rejeter d'une manière absolue la présence de la synoviale sur les cartilages, je dirai seulement que la plupart des faits relatifs aux maladies des articulaires que j'ai eu occasion d'observer—ne sont pas favorables à cette présence*".

Frerichs (1846) believed in the existence of an epithelium on the surfaces of articular cartilage, an opinion which was not shared by Gerlach (1849), who believed that the superficial flattened cartilaginous cells and limited ground substance should be regarded as an epithelial layer on the joint surface. Reichert (1849) on the other hand wrote, "*Im Fötalzustande des Menschen und der Haussäugethiere liess sich an der ganzen inneren Oberfläche der Synovialkapseln Epithelium nachweisen. Auf dem Gelenkknorpel lag desselbe unmittelbar auf der Knorpelsubstanz auf.*"

Todd and Bowman (1857) wrote, "*The articular synovial membrane* forms a closed bag, placed between the articular surfaces of the bones. Its free surface is smooth and moist; its attached surface adheres by very fine areolar tissue to the ligaments of the joint, and to the cartilages encrusting the extremities of the bones."

Synovial membranes were regarded as continuous over diarthrodial cartilages because, if an oblique cut is made into the cartilage of the joint and the small segment is fractured, it will remain connected to the rest of the cartilage by a thin membranous layer, which grossly might be taken for a synovial membrane. Likewise, if a cut is made longitudinally through the shaft of a long bone and into the articular cartilage and the segments then forcibly separated, the fragments are held together by a membrane. Toynbee (1841), for example, removed "the synovial membrane from nearly the entire surface of the articular surface of the condyle of the femur" of the foetal calf, and some observers reported seeing blood vessels extending over the articular cartilage. Moreover, adhesions were seen passing from the cartilage to the other parts of the joint in certain arthritic conditions, and since bursae mucosae, serous membranes, and tendon sheaths are closed sacs, reasoning by analogy made synovial membranes closed sacs.

Those who denied the presence of the synovial membrane over the cartilage held: (1) that the thin layer demonstrable by slicing the cartilage, and lifting it up as described, was only a very thin lamina of cartilage; (2) that the vessels covering the cartilage, if present, cannot be demonstrated even by the best of injections; (3) that the inflammations always stop at the margin of the cartilage; and (4) that if a membrane extended over cartilage it would secrete synovia, which was disproved by Cruveilhier's experiment, demonstrating the fact that synovia reappeared on the membrane lining of the joint but not on the cartilage after being wiped off both surfaces.

When cartilage was carefully studied microscopically, it was generally conceded that the synovial membrane did not cover areas of movable contact of articular cartilages. The "margin zone" between the synovial membrane and the joint cartilage was described by Reyher (1874) and later by Ogston (1876) who demonstrated how the synovial fringe "would gradually end by passing into the cartilage layer next to the joint surface", a view which was also held by Robin and Cadiat (1881). Soubboutine (1880), however, held that "*la membrane synoviale ou, ce qui est la même chose, le ligament capsulaire de l'articulation est une véritable glande close, destinée à la production de la synovie*", and as late as 1884 Aubrey wrote, "*Ces membranes tapissent l'intérieur des articulations; étendues entre les divers éléments qui constituent celles-ci, elles les relient entre eux et forment des véritables cavités closes*".

Although the histology of the synovial membrane has interested many anatomists, no definite agreement regarding it has been reached even today. Synovial and serous membranes were considered to be alike in structure and function, both being lined by a single layer of epithelial cells. In 1852 Brinton wrote, "The epithelium of these structures presents characters which afford some grounds for distinguishing it both from that of the bursae and serous membranes. It forms for the most part but one layer, the forms of the constituent cells of which vary to the same extent as those witnessed in the bursae. But the broad, squamous, polygonal epithelia are comparatively rare; and in by far the larger extent of its surface the predominant shape is that of a slightly flattened spheroidal or oval or somewhat angular cell." Todd and Bowman (1857) in comparing synovial with serous membranes said, "These membranes appear to be essentially alike in their minute structure. On their free surface is a single layer of epithelium, the particles of which are polygonal in shape, and of transparent texture." Henle (1865) described the synovial membrane as a simple pavement epithelium.

The silver-impregnation method introduced by von Recklinghausen (1860) was adapted by Hueter (1866) for the synovial membrane. Hueter denied the existence of an epithelium, and his work seemed to displace the synovial membranes from the position they had so long occupied with the serous or mucous membranes. He wrote, "*Die Intima der Synovialhaut hat keinen Überzug von Epithel, sondern besteht aus zellenreichen Bindegewebe*".

He described the cells as "epithelioid" or "keratoid" in character. Opposition to the researches of Hueter was initiated by Schweigger-Seidel (1866) who demonstrated, to his own satisfaction, that the markings obtained by Hueter were artifacts. He attempted to prove the existence of a single-layered epithelium from the arrangement of the nuclei on the surface, although the cell outlines were not visible. Sappey (1867) also described an epithelium in the following words, "*La couche épithéliale est formée de cellules aplaties qui se juxtaposent et qui constituent plusieurs plans superposés; elle réprésente, en un mot, un épithélium pavimenteux stratifié*".

By using a weak silver-nitrate solution, Landzert (1867) found a continuous flat epithelium (endothelium) on the inner surface of articular capsules and believed he saw lymphatic vessels. On the other hand, according to Albert (1871), the results obtained by Böhm (1868) with silver-impregnation methods confirmed the work of Hueter, but on further investigation with fresh preparations in salt water, Albert considered that the inner layer of the joint capsule was composed of non-nucleated cells.

Cornil and Ranvier (1869) considered the synovial membranes as covered with a single layer of epithelial cells resembling those in serous cavities, and Frey (1871) also placed them with the serous membranes.

By macerating a joint for a few days in a weak solution of chromic acid, Albert (1871) was able to separate a complete, continuous layer from the internal surface of the synovial membrane, the cells appearing round or polygonal in shape with short processes, with rounded or oval nuclei. In silver preparations, two layers of cells were observed over large areas of the synovial membrane, the superficial layer exhibiting markings resembling endothelium, and the underlying layer containing the characteristic vascular plexus composed of rhombic and quadrilateral meshes and the included "*Saftcanälchen*". Tillmanns (1873–1876) opposed the views of Hueter, and was of the opinion that the inner layer of the synovial capsule was clothed with a single continuous layer of epithelium.

Gold-chlorid solutions (one-ninth to one-twelfth per cent.) were used by Steinberg (1874) in his researches on the structure of the synovial membrane from the knee joint of the dog and cat. He affirmed the presence of a single layer of endothelium on the inner surface of the synovial membranes and considered them as serous membranes.

Reyher (1874) confirmed the results of Hueter on adult tissue by studies on embryonic tissue. He wrote, "In spite of the difficulties presented by the softness of the embryonic tissue to subjecting silvered portions of the synovial membrane uninjured to the microscope, I have nevertheless been so far successful, and I am able to confirm, in every respect, in the embryonic tissue the observations of Hueter upon the adult; and I must distinctly deny the existence of an epithelium . . .".

Van der Sluijs (1875) regarded the synovial membrane as connective tissue very rich in cells on the free surface, the cells belonging to the group of round connective-tissue-like cells distinguished by Waldeyer. He believed that the markings obtained by Hueter were artifacts. Bentzen

(1875), however, writing in the same year, believed that the inner layer of the synovial capsule was clothed with a layer of epithelium.

A new view was adopted by Tourneux and Herrmann (1880) who described the lining cells as follows: "*Chez le boeuf et le cheval les cellules périphériques affectent une forme nettement prismatique ou cylindrique avec le noyau relégué à la base de l'élément. Nous considérons le tissu qui résulte de cette disposition comme un tissu spécial, sans analogue dans l'économie, dérivant probablement du tissu cartilagineux, et n'ayant de commun avec le tissu épithélial que l'absence de vaisseaux et la configuration extérieure des éléments qui le constituent.*"

Hagen-Torn (1882) said, "*Die Zellenreihen bilden keine continuierliche Schicht, sondern sind ganz ohne irgend welche Ordnung in eine feinkörnige, verfilzt-faserige Schicht der Synovialis eingestreut, hie und da in grösserer Menge zusammenhäuft auf kurzen Strecken in einer oder zwei Reihen angeordnet, ohne genauer zu bestimmende Gesetzmässigkeit. Das unterliegende Gewebe zwischen dem fibrösen Bindegewebe der Gelenkkapsel und der beschriebener zellenreichen Schicht (der Intima der Autoren) bildet eine verschieden dicke Schicht weitmaschigen, lockeren Bindegewebes welches auch zwischen den einzelnen Schichten der Kapselbänder anzutreffen ist.*"

Kölliker (1889) described the synovial membrane as consisting of an outer connective-tissue layer and an inner cellular endothelium consisting of three to four superimposed layers, and Lovett (1894) maintained that synovial membranes were closely related structurally to the serous membranes, holding that, "Histologically the structure is a basement tissue of elastic connective-tissue fibers, upon the inner surface of which lies a single layer of endothelial cells". He appeared to think the method of Hueter faulty.

The controversy regarding the structure of the inner layer of the synovial membrane appeared to be settled when Hammar (1894) and Braun (1894), working independently of each other, reached results which were very similar. Hammar described the "intima" of the synovial membrane as consisting of connective tissue of cell-rich and cell-poor types. He called the superficial cells "synovial cells" and found they were nearly all branched, varying greatly in size, thickness, and manner of branching, possessing one or two nuclei, sometimes packed close together, and in other places widely separated, and here and there arranged in a single row presenting an endothelial-like picture. Braun showed that although the surface cells lie very close together, often appearing "epithelioid", they had in most cases branching processes with wide or narrow intercellular substance between them, the cells lying in a liquid canal system in which wandering cells were often present.

Hofbauer (1898) made special studies of the capillaries in relation to disease, and failed to confirm the opinion of former authors that the epithelium of the capillaries extended uncovered into the joint cavity.

Fick (1904), in writing about the inner lining of the synovial membrane or "*Gelenkinnenhaut*", adopted the view of its structure already

presented by Hammar and Braun; and the researches of Kroh (1908) on human foetal knee joints were in accordance with the results obtained by Hueter, Hagen-Torn, Hammar, and Braun. Kroh disposes of the so called endothelial layer in the following words: "*. . . schliesslich rücken die Zellkörper so nahe aneinander heran, dass die zwischengelagerte Grundsubstanz schmäler und schmäler wird, im Oberflächenbilde als feines Maschenwerk erscheint und einschliesslich der in den Maschen eingelagerten Zellen als 'Endothel' fraglos imponieren kann. Diese Täuschung fällt weg, wenn man bei scharfem Zusehen eine Anastomosierung dieser Oberflächenzellen mit tiefer gelegenen Zellkörpern vereinzelt, aber exakt nachzuweisen lernt.*"

Lovell and Tanner (1908), in contrasting synovial with serous membranes, observed, "In synovial membranes we only find isolated patches of epithelial cells; in serous membranes there is a continuous pavement epithelium . . .". Stöhr (1910) wrote of the inner layers, saying "*letztere sind bald nur spärlich vorhanden—an Stellen, wo grösserer Druck ausgeübt wird,—bald sind sie sehr reichlich und bilden formliche Epithel (Endothel)—lagen, die in 3-bis 4-facher Schicht die Innenfläche decken*"; and Piersol (1910) believed that the synovial membrane consists of loose flattened connective tissue cells forming for the capsule a lining that resembles an imperfect endothelium.

Lubosch (1910) in his comprehensive work *Bau und Entstehung der Wirbeltiergelenke* wrote on the structure of the synovial membrane, "*Mann ist ohne weiteres darüber einig, dass die Tiefe der Synovialhaut aus derben Bindegewebsbündeln besteht, die zwischen sich Spalten lassen, vergleichbar den Spalten zwischen den Bündeln der Hornhaut. So wie in diesen Spalten der Hornhaut, liegen auch in den Spalten der Synovialmembran die Synovialzellen. Die Zellen sind Bindegewebszellen.*"

Apparently the work of previous investigators was not convincing, for Prenant, Bouin, and Maillard wrote in 1911, "*La structure de la couche superficielle ou intime, qui borde directement la cavité articulaire, est très controversée*"; and Poirier and Nicolas in the same year stated that "*Les membranes synoviales sont constitutées—(1) par une couche de tissu conjonctif renfermant de fines fibres élastiques, des vaisseaux et des nerfs; (2) par une couche interne, qui confine immédiatement à la cavité de l'articulation et dont la nature est encore un objet de controverses, sans compter que son existence même a été mise en doute*". As late as 1923 Howden wrote in Gray's Anatomy, "It is composed of thin delicate connective tissue, and is covered on its free surface with a layer of endothelium", but Magnus in the same year discreetly wrote, "*Für unsere Fragestellung ist dieser Punkt ein Streit ums Wort, und wir können ihm mit dem Begriff der 'Intima', der nichts präjudiziert, gut aus dem Wege gehen. Die Gelenkkapsel besteht also in allen ihren Schichten aus einer Grundsubstanz, in welche die Zellen eingestreut sind. Je näher der Oberfläche, desto dichter rücken die Zellen, desto mehr geht der 'keratoide Typus' des Bindegewebes in den 'epithelioiden' über*". (Hueter).

Fisher (1923) concluded that, "Here and there the endothelial layer is absent, and at these spots the loose connective-tissue layer abuts directly

upon the joint cavity"; but Jordan (1924) stated that, "The synovial membranes resemble the serous in their structure. They are clothed by a single layer of pavement cells which is said to be incomplete in places."

Bremer (1927) on the contrary declared that "The 'epithelium' is a smooth glossy layer of connective tissue with parallel fibers and small round or stellate cells containing large nuclei"; and Bailey (1927) stated that, "On the free surface, however, the cells are closely packed and although in places often several layers deep, are probably of the nature of endothelium". Clark (1928) in a preliminary report on the structure of the synovial membrane wrote, "In conclusion, it is believed that a joint cavity is to be regarded functionally as a closed sac lined, except at points of mechanical pressure, by a layer of cells modified to form a true mesothelial lining".

In the past, the structure of the synovial membranes was considered to be relatively simple, being regarded as composed of connective tissue with an inner endothelial lining, and they were readily placed with the serous membranes; but as a result of numerous special investigations doubts were raised concerning the inner lining, some authors affirming its presence, others denying it; so today, the problem is still unsettled.

This brings the subject matter up to date. Several articles have been omitted due to the fact that they were merely accounts of research already described. The importance of the problem justifies the large amount of work done and the numerous papers published on the subject. But conclusive experimental data dealing with the structure and function of the synovial membranes have not yet been presented.

For a long time anatomists have been working on its structure, the papers by Hueter, Hagen-Torn, Hammar, and Braun being of outstanding merit. On the other hand, very little work on the physiology of the synovial membranes has been published. The result is that the normal functioning of joints, and the part taken by the synovial membranes in this process is, as yet, little understood. Since structure and function are so intimately associated, it does not appear that a complete knowledge of the anatomy of the synovial membranes can be gained, until a large amount of additional evidence as to their relation to the functioning of diarthrodial joints has been presented.

Since the structure, function, and relations of the so called synovial membranes are unsettled and of importance to the anatomist, pathologist, and orthopaedic surgeon, further research on this problem appears warranted.

Material and Methods

The material used for this research consisted of the joints of animals (guinea-pig, rabbit, cat, and dog) and human joints (foetal and adult). The human foetuses used were selected from a large collection of various ages, and were in an excellent state of preservation. Most of the adult material was from dissecting-room bodies ranging in age from twenty-one

to ninety-one years. On account of its size and convenience the knee joint was used for the most part, but the ankle and shoulder joints were also studied.

The preserved material was hardened in alcohols, imbedded in paraffin, sectioned, mounted, and stained with hematoxylin and eosin. The fresh tissues were fixed in formalin (5 per cent.), Müller's solution, or Zenker's solution, imbedded and cut in the usual manner, and then stained with hematoxylin, eosin, van Gieson's or Mallory's connective-tissue stains. Silver nitrate of various strengths was employed on the fresh tissues in the study of the intercellular substance to demonstrate the margins of the surface cells. In some cases, gold chlorid was used. Injections into joints were made with Berlin blue, trypan blue, India ink, colloidal silver, silver nitrate, and gold chlorid, and the tissues studied were both fresh and fixed.

The effect of joint immobilization was observed on a small series of rabbits, the ankle joint being selected on account of the ease of plaster-cast application.

To demonstrate fat in the tissues, the freezing microtome was employed, the sections being cut at about thirty microns and subsequently stained with Sudan III and hematoxylin. Ranson's pyridin technique was used in the demonstration of nerves.

Macroscopic Structure

On opening any diarthrodial joint, the smooth, thin, soft, whitish synovial surface of the capsule presents itself, and in certain regions, particularly near the cartilaginous margins, fatty appendages, or haversian fringes are often found. This translucent inner portion is the so called synovial membrane. When rubbed between the fingers it gives a slippery sensation due to the presence on its surface of synovia, which is a fluid supposed to be secreted by the synovial membrane.

On account of the ease with which the superficial layers on the articular surfaces of hyaline cartilage could be stripped off, the older anatomists concluded that synovial membranes continued over these surfaces, but this conception has long been known to be incorrect. On subjecting this thin, translucent, membrane-like layer to microscopic examination, it is found to be composed of a thin fibroid layer with numerous degenerate nuclei disposed longitudinally. That this layer is not truly fibrous is demonstrated however by its failure to take the special connective-tissue stains. Although the synovial layer of the articular cartilage is not continuous over the articular cartilage, it gradually blends with the superficial fibroid layer of the articular cartilage at the "marginal zone" of the latter.

Microscopic Structure

For the first part of these histological studies material from six foetuses, preserved in formalin, and varying in age from five to nine months, was selected. Small portions of the capsule were taken from the lateral surface

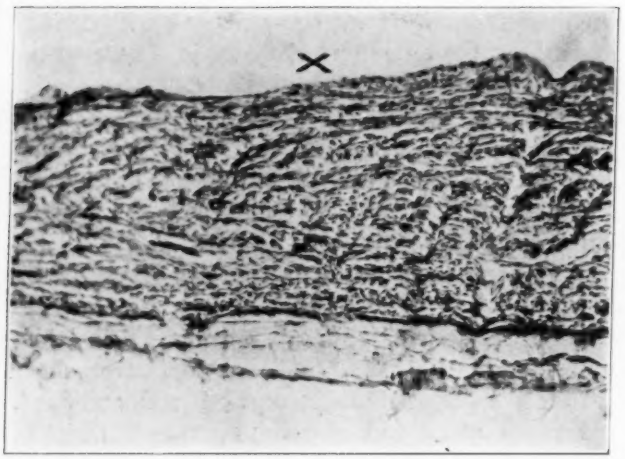

FIG. 1

Photomicrograph from the capsule of a knee joint taken from a five-months' foetus. Note the lack of differentiation between the surface cells marked x and the underlying connective tissue. × 70.

of the knee joint between the patella and the lateral condyle of the femur. The sections were stained with Delafield's hematoxylin and counterstained with eosin or van Gieson's, after hardening and imbedding in the usual manner.

In sections from the joint capsule of a five-months' foetus (Fig. 1) it is evident that there is very little, if any, differentiation between the synovial surface and the subjacent fibrous connective tissue. The deeper-lying connective-tissue cells are provided with branching processes and circular, deeply staining nuclei, which gradually become flatter as the synovial surface is approached.

No definite epithelial or endothelial cellular layer, such as described by some authors, is present, but some differentiation seems to have taken

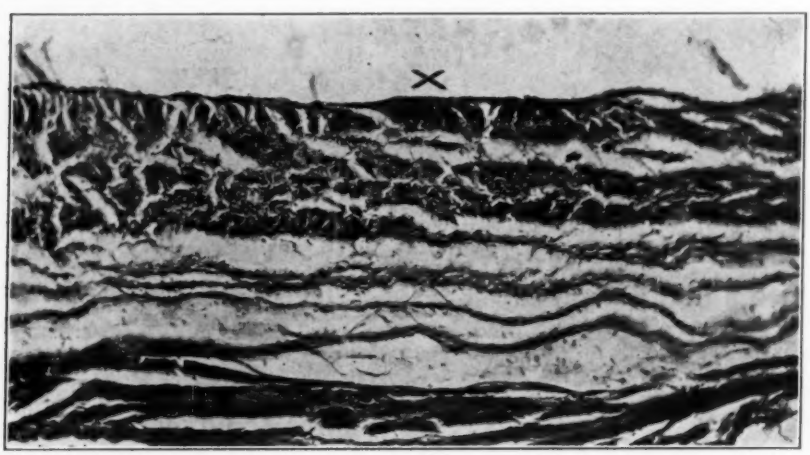

FIG. 2

Photomicrograph from the capsule of a knee joint taken from a nine-months' foetus, showing in addition to the capsule above, subjacent connective tissue and muscle. In this specimen a superficial condensation line (x) is visible, which, however, is not a layer of specialized cells like those in serous membranes.

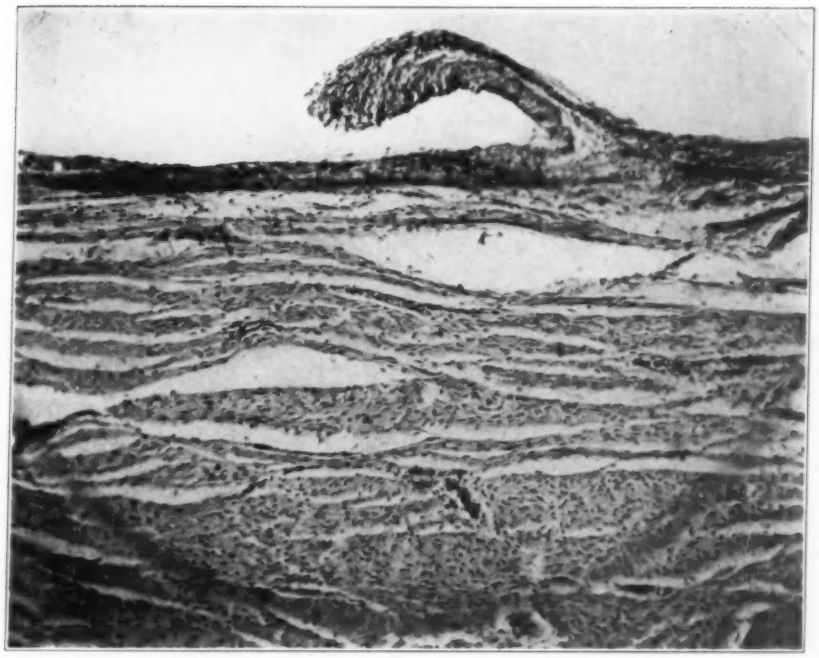

FIG. 3

A portion of the synovial capsule and adjacent tissues from an eight-months' foetus, showing a synovial villus without a membranous covering. × 70.

place in the surface cells from the joints of the eight- and nine-months' foetuses (Figs. 2 and 3), for they are flattened and their processes are not confined to the surface but dip down into the deeper connective tissue, and the nuclei for some reason stain deeper. The cytoplasm of these branching cells is abundant and the nuclei are circular or oval in outline.

Figure 3 is a photomicrograph of a section from the capsule of an eight-months' foetus showing a so called synovial villus attached to its surface by a narrow stalk. The structure of this villus is the same as the part of the capsule from which it projects, and no differentiation is apparent in the superficial cells of either.

Specimens from adult human bodies were taken at random from the dissecting room where most of the cadavera were from fifty to eighty years of age. The articular capsules from the knee and shoulder joints were for the most part studied after fixation and imbedding in the usual manner. In all of the sections examined, the nuclei of the surface cells were closely packed and stained deeply. The underlying connective tissue was loosely arranged with cells of abundant cytoplasms and small round or oval nuclei which did not stain as deeply as the nuclei of the superficial cells. A very rich capillary anastomosis was present and particularly well marked near the free surface where the vessels were covered by only one or two layers of cells as shown in Figure 4. In this illustration some of the synovial fluid

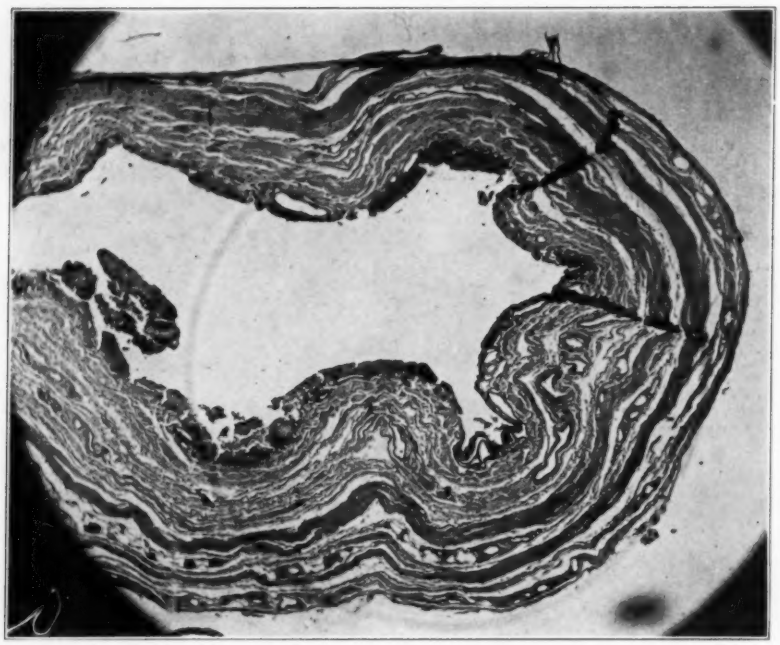

FIG. 4

A portion of the capsule of the knee joint from a man aged sixty-two. The synovial surface is on the concavity. A rich capillary plexus extends up to the synovial surface and at the left a small free body is shown. × 50.

is shown coagulated on the surface and a free cartilaginous fragment is visible.

In adult humans the inner synovial surface may become modified structurally and the synovial capsule may be partly or wholly destroyed as a result of attrition. Meyer (1915) reported this condition, and found it most commonly in the shoulder joints of men in the later decades of life. In 1924 he stated, "The walls of synovial bursae, articular capsules, discs, menisci and cartilages, and even tendons in contact with bones may be partly or wholly destroyed by friction in the course of years".

In some experiments the effect on the inner synovial cellular layer of the injection of vital dyes into the joint cavity was studied. One hour after the injection of a solution of trypan blue (vital) into the knee joint of a cat, the animal was killed. After fixing, hardening, imbedding, and sectioning of a portion of the capsule, microscopic examination showed that the surface cells did not differ markedly from the subjacent cells in their ability to take up the dye (Fig. 5). The staining was deepest at the surface and gradually became lighter toward the interior. On injecting this dye into the knee joint of a dog which had been dead for ten minutes, only the most superficial cells were stained, the underlying connective tissue being free from the dye (Fig. 6).

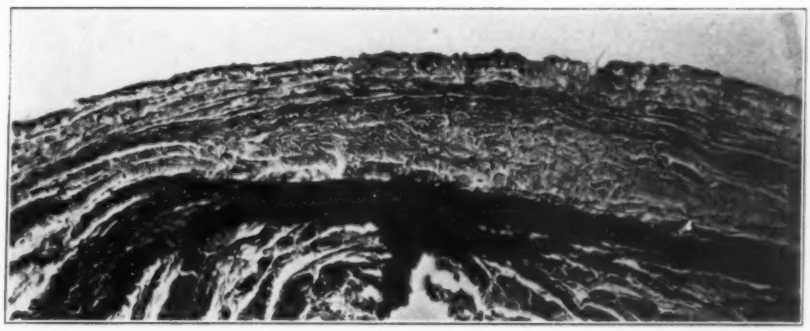

FIG. 5

Articular capsule and adjacent tissue from the knee joint of a cat. Trypan blue (vital) was injected into the joint and the animal killed five minutes later. The dye penetrated below the surface for a short distance. The preparation was stained with van Gieson's. × 70.

In rabbits, trypan blue was injected into the knee joints at intervals of two to three days and the inner surface of the joint capsule scraped off and examined immediately in a drop of physiological salt solution. Some of the cells were found to contain more of the dye than others. These are probably the macrophages of the connective tissue, for Evans and Scott (1921) found that trypan blue showed a greater affinity for these cells than for the fibroblasts.

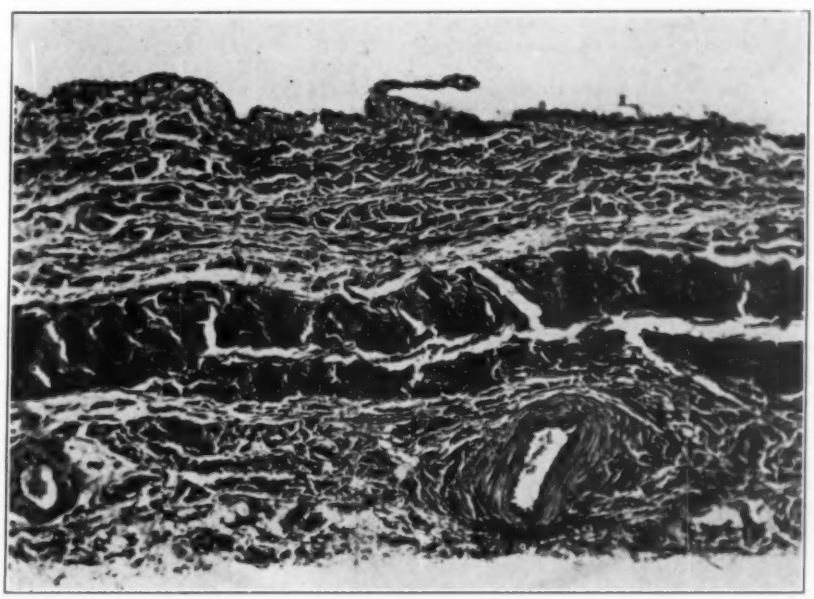

FIG. 6

Capsule and adjacent tissue from the knee joint of a dog. Vital trypan blue was injected ten minutes after the death of the animal. In this case only the surface cells were stained. A small villus is seen projecting from the free surface. × 70.

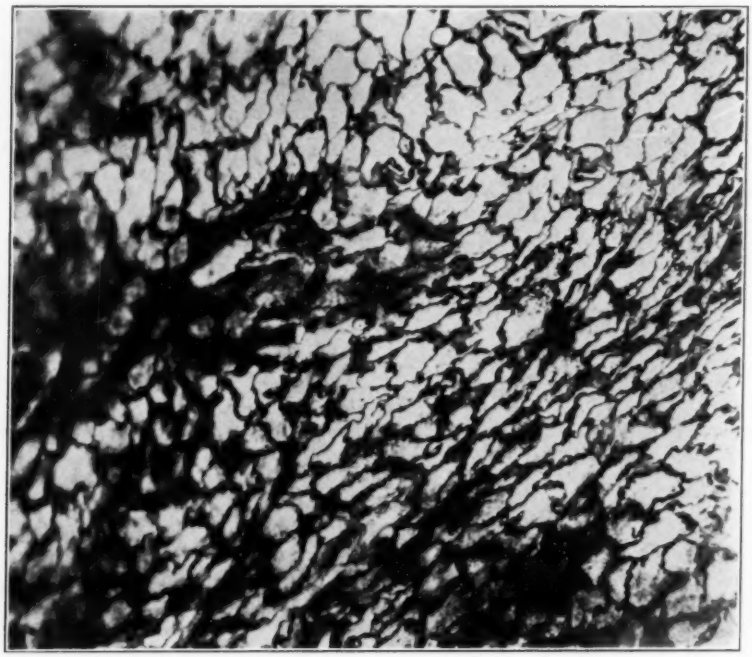

FIG. 7

Photomicrograph of the synovial surface from the knee joint of a rabbit, which had been treated with a one-per-cent. solution of silver nitrate. The dark areas are due to unevenness of the specimen. × 235.

My studies on the structure of articular capsules appear to show that the inner cells on the synovial surface do not form an endothelium or epithelium, although many recent textbooks and authors still present this view. The question then arises as to the nature of these cells, and whether or not they regenerate after removal as, for example, in the operation of "synovectomy". When cells are scraped from the synovial surface of the capsule, or when they are found in the synovial fluid, they are seen to vary greatly in size and shape. Some are quite large with one or more processes, and others are small and spindle-shaped. The nuclei are usually placed near the center of the cell and are round or oval in shape.

The researches of Segale (1913), Key (1926), and Wolcott (1927) on the experimental removal of this part of the capsule, show that regeneration of the "synovial layer" occurs as a result of a metaplasia of the underlying connective tissue, thus forming "a synovial lining which can be distinguished only with difficulty from that of the normal joint" (Key). In the rabbit, Key considers that the joint is normal in about sixty days. These findings do not give support to the theory that articular capsules are provided with an epithelium on their inner surfaces. If such were the case, we would expect the edge of the curetted area to show signs of proliferation, with a spreading inwards and laying down of young epithelial cells on the surface, which is contrary to the observations of these investigators.

Curettage of the inner portion of the articular capsule is an operation which has been inappropriately named "synovectomy". This operation was probably first performed by Volkmann in 1877, who first used this procedure in a case of tuberculosis of the knee joint. This operation has become quite popular in recent times for certain joint diseases. In these cases, regeneration over the curetted area from the underlying connective tissue is probably complete. Swett (1925) said: "In two cases which came under my observation several months after synovectomy, I found a replacement of synovial membrane with no evidence of scar tissue". However, if the articular capsule is not provided with an endothelium or a clearly differentiated inner cellular lining, the question arises whether the term "synovial membrane" is justified and whether one can truthfully speak of restoration of it.

Impregnation with Metallic Stains

Certain metals—such as silver, gold, and osmium—possess the property of staining tissue elements, because they are either directly reduced from appropriate salt solutions or because they are taken up and rendered prominent when the metallic salt is reduced later.

Silver in the form of silver nitrate has enjoyed the greatest popularity since its introduction by von Recklinghausen (1863). Its first application to the synovial membrane was made by Hueter and subsequently by Land-

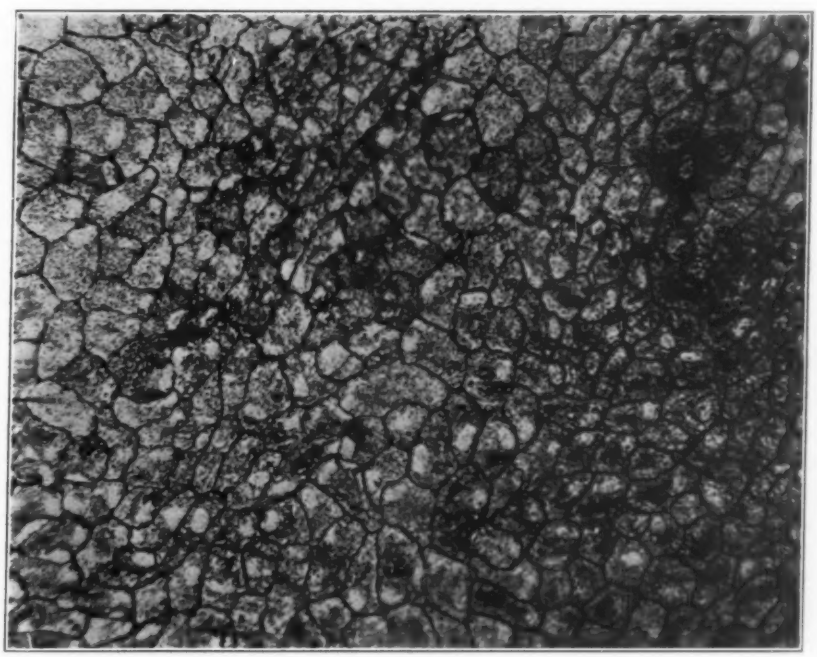

FIG. 8

Photomicrograph of the peritoneum from the same rabbit treated as that in Fig. 7. The difference in the mosaic is pronounced. × 235.

zert, Hagen-Torn, Hammar, and others. Its action is to stain brown or dark brown the cement substance between endothelial and epithelial cells and the ground substance of connective tissue.

The greatest difficulty and objection to this method lies in the fact that albuminous fluids are apt to form granular, thread-like coagula which may easily be mistaken for cell outlines. In the joints, the synovial fluid, on account of its high albumin content, may produce artifacts on the "intima" of the joint capsule, which must be guarded against. Tillmanns and others strongly opposed its application to joint capsules on this account, but subsequent investigators have supported the findings of Hueter.

As a preliminary measure to the application of silver, the fresh capsule as it is excised from the knee joint is washed with a two-per-cent. solution of sodium nitrate or one-per-cent. solution of sodium sulphate or distilled water. In this way precipitation in the synovia is prevented. Care must be taken to keep the tissue tightly stretched because a silver precipitation occurs where folds are present.

The silver nitrate is usually applied in strengths of 1:300 or 1:500 up to two per cent. I have found that a one-per-cent. solution with short exposure to sunlight brings out the clearest images. A method that I have frequently used with success is to strip off the outer portion of the capsule, leaving the delicate, inner layer attached to the patella and condyle of the femur. Then by carefully removing this tissue and placing it on a slide and treating it with a silver solution very clear outlines can be obtained. The pleura and peritoneum were used as controls. (See Figure 8.)

In Figure 7, a photomicrograph of the synovial membrane, and in Figure 8, one of the peritoneum, both treated in a similar manner with silver nitrate, are shown. A marked contrast is present. The ground substance in both cases is dark brown, but in the peritoneum this is less in amount, so that the cells are closely packed in a pavement layer, whereas in the synovial membrane this ground substance is much greater in amount with the cells arranged in an irregular manner. The cells also vary greatly in size and shape, and while their margins are serrated, their union with adjacent cells is very irregular and upon close inspection the cell margins are seen to overlap other adjacent cells. Where the cellular layer is thick, adjustment of the microscope is necessary to bring them into view and the former picture fades and is replaced by another.

In silver preparations, there appears to be no uniform superficial cell type but a variety of cells, some small and round with no processes, and others large and irregular with numerous processes. In some preparations the picture changes and a double cell margin seems to be present, but this seems to be due to the staining of the underlying cells. An endothelial-like picture is seen in some positions where the cells are more uniform in size with their margins arranged in a pavement-like layer.

That the synovia is responsible for this silver precipitation in these preparations is, of course, possible, but the images obtained in a large number of cases are quite similar.

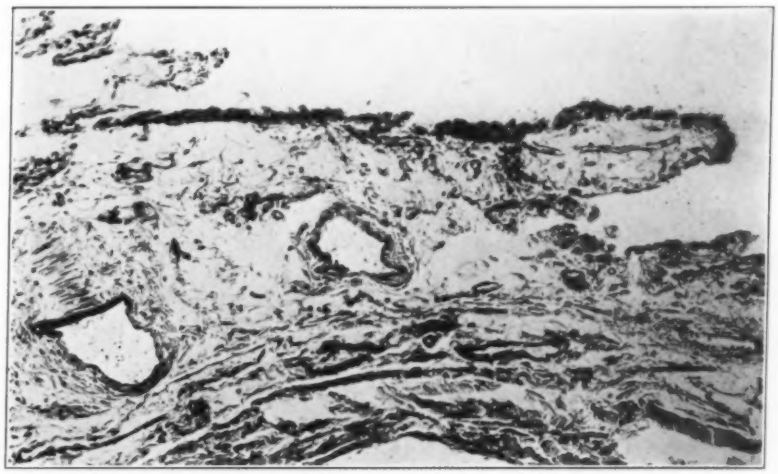

FIG. 9

A portion of a capsule from the knee joint of a four-months-old rabbit, containing a blood vessel cut longitudinally. × 95.

By taking silver preparations, prepared as described, and fixing, hardening, imbedding, and cutting them transversely, it becomes evident that the silver penetrates for a short distance, and only affects the superficial two or three layers of cells.

A method of Hoyer (1867) described by Lee (1928) consists in adding ammonia to the silver nitrate; the solution so formed is supposed to impregnate the endothelium or epithelium, leaving connective tissue unaffected. This was tried on both the peritoneum and the articular capsules of rabbits. In the peritoneum, the endothelial cells with the underlying lymphatics were readily demonstrated while the synovial surface of the articular capsule was unaffected.

In some of these silver preparations, intercellular spaces are present which may appear like openings between the joint cavity and the lymphatics in the synovial capsule. These spaces were called "stomata" and their presence in synovial capsules was affirmed by Mosengeil (1876) and Baum (1911) and more recently by Fisher (1923) who in describing the synovial membranes said, "At the parts most remote from the articular edges it consists of a single layer of endothelial-like cells which in places surround openings or stomata". On the other hand, Magnus (1923) wrote, in the same year, "*Die Frage der Stomata ist damit in negativem Sinne entschieden*", which is in direct opposition to Fisher's view. This conclusion was based on experiments with hydrogen peroxid, with which Magnus believed the presence of stomata in the peritoneum of the mouse was successfully demonstrated.

The synovial surface of articular capsules, when treated with weak solutions of silver nitrate, exhibit at times artifacts which appear like "stomata", but they are most probably thread-like or granular deposits

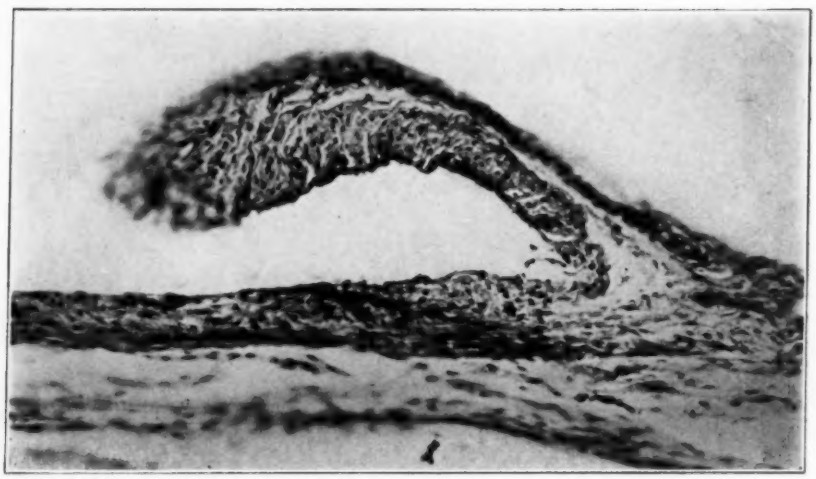

FIG. 10

Villus from the knee joint of an eight-months' foetus with a similar blood vessel. × 170.

due to the coagulation of albumen. It has been demonstrated that stomata and stigmata can be produced by the addition of a weak solution of silver nitrate to a mixture of egg albumin on a slide and subsequent exposure to sunlight in the usual manner. The action of silver nitrate on the synovial fluid is probably the responsible factor in the production of these artifacts which cannot be regarded as stomata without more proof than has so far been presented.

Although large intercellular areas were outlined in many of my silver preparations, in some portions on the inner surface of the capsule, it is not safe to assume that these are open communications between the joint cavity and the lymphatic plexus of the underlying connective tissue.

In studies on the absorption of carbon particles and other foreign bodies from joint cavities, I have never seen any openings or stomata, and in this respect my observations are in accordance with the findings of Zalewski (1928), who studied the lymphatics in articular capsules. He wrote, "*Le résultat de nos études sur la structure de la capsule articulaire et le système lymphatique nous amène à nous prononcer contre une pareille communication directe et nous partageons l'opinion de ces auteurs qui décrivent le système lymphatique de la capsule comme complètement clos et ne possedant aucune communication ouverte avec la cavité articulaire*".

The theory of the so called "stomata" and "stigmata" was initiated by the researches of von Recklinghausen (1863) who introduced silver-impregnation methods in microscopic technique. Subsequent writers gave support to this theory, particularly Dybkowsky (1866), Schweigger-Seidel and Dogiel (1866), and Klein (1873). Klein even described two types of stomata on the surface of serous membranes, stomata vera and stomata spuria.

Many authors, however, denied the existence of stomata. Ranvier (1889) showed that fewer stomata were present after preliminary washing of the tissue with distilled water. Kolossow (1893) found no stomata in serous membranes. Meyer (1900), working on the peritoneal epithelium of the cat, concluded that, "There are no preformed natural openings commonly called stigmata and stomata", a statement which was further supported by the work of MacCallum (1903), Walter (1912), Hertzler (1919), and others. The words of Hertzler, ". . . the subject no longer offers a fruitful field for investigators", will serve in summing up this point.

Synovial Villi

According to Soubboutine (1880), synovial villi were first described and named "*Synovialzotten*" by Luschka, probably because of their slight resemblance to intestinal villi. In describing these villi, Soubboutine (1880) wrote, "*Les villosités synoviales sont recouverts de cellules cylindriques ou polyhédriques qui ont le caractère de cellules glandulaires, analogues aux cellules des glandes à mucus; il s'y rencontre aussi de cellules caliciformes semblables à celles de la muqueuse intestinale*".

The synovial villi project into the joint cavity from the inner surface of the joint capsule by a pedicle or stalk which is usually quite narrow. They vary in size and shape, some being short and gradually tapering to a point or having a blunted extremity (Fig. 9). Others are club-shaped with long narrow stalks (Fig. 10), and yet others are long, narrow, and somewhat cone-shaped (Fig. 11). Many of these villi are composed of only two layers of cells (Fig. 6).

The structure of the villi is similar to the part of the joint capsule from which they project, being composed of modified connective tissue, the cells having branched processes and deeply staining nuclei. In many of these

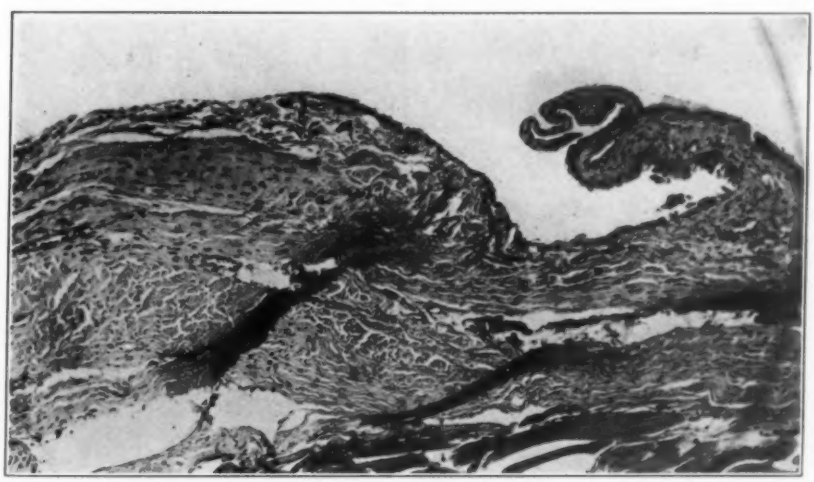

FIG. 11

A portion of a capsule from the knee joint of a guinea-pig, showing a long villus folded upon itself, probably during fixation. × 70.

FIG. 12

Photomicrograph of the capsule from the knee joint of a miner aged ninety-one, showing a synovial villus to the left containing several blood vessels. × 170.

FIG. 13

Photomicrograph of the capsule from the knee joint of a woman aged thirty-four, showing a synovial villus to the right. × 230.

FIG. 87.—SYNOVIAL VILLI WITH BLOOD VESSELS FROM A HUMAN KNEE JOINT. × 50.

The epithelium has fallen from the apex of the left villus, exposing the connective tissue.

FIG. 14

An illustration (Fig. 87) appearing in Bremer and Lewis's "Textbook of Histology" (Ed. 3, p. 109, 1927), showing the epithelium sloughed from the left villus. (Reproduction has been enlarged about three-tenths.)

projections, the cells are spindle-shaped and distributed throughout in a uniform manner. In some of the villi the nuclei of the superficial cells stain more deeply than those of the subjacent cells, thus presenting an appearance which has often been described as "epithelioid" (Fig. 12). Others, however, show no differentiation between the superficial and subjacent cells as illustrated in Figure 13, which is from a capsule removed from the knee joint of a woman thirty-four years of age. Two villi are present, neither of which has an epithelial covering. A comparison can be drawn between this figure and Figure 14 after Bremer and Lewis (1927). In the accompanying legend it is stated that this is an illustration of a synovial villus from a human knee joint and that "the epithelium has fallen from the apex of the left villus, exposing the connective tissue". In another recent textbook of histology, that by Jordan (1924), a most remarkable illustration of the "tip of a villus of the synovial membrane from the knee-joint of an old man" is presented. This illustration with its legend is reproduced in Figure 15. Jordan states that the epithelium in synovial membrane is of the low columnar or cuboidal type, with a distinct basement membrane in certain regions. Figure 12 is a photomicrograph of a villus also from the knee joint of a man of ninety-one years. The contrast between these two illustrations is marked, and I have never observed any synovial villus resembling either Figures 14 or 15 with cuboidal epithelium or with epithelium, some of which has fallen away. Another illustration (Fig. 240) in Jordan is said to be that of a "section of a vascular synovial villus from the knee joint of a child", but no distinct epithelium is represented on it as in Figure 15. This implies that the superficial cells become specialized, forming a cubical or columnar epithelium with advancing age!

FIG. 44.—TIP OF A VILLUS OF THE SYNOVIAL MEMBRANE FROM THE KNEE-JOINT OF AN OLD MAN.

The core contains capillaries embedded in a compact, delicately fibrillar stroma. A distinct basement membrane appears in certain regions. The epithelium is of the low columnar or cuboidal type.

FIG. 15

An illustration (Fig. 44) appearing in Jordan's "Textbook of Histology", p. 39, 1924.

In describing the end results of arthroplasty of the knee, Campbell (1928) presents an illustration (Fig. 12, *The Journal of Bone and Joint Surgery*, X, 829, Oct. 1928) which is a "photomicrograph of specimen from

arthroplasty of knee, showing formation of villus, the surface of which is covered by a cellular membrane, probably resulting from the remains of the synovia". I assume that Campbell means synovial membrane and not synovia, but the assumption that the synovial membranes are responsible for the production of a definite cellular covering for villi seems unwarranted.

Synovial villi are usually vascular as shown in Figures 9 and 10. Figure 9 shows the villus from the knee joint of a four-months-old rabbit and Figure 10 is a villus from the knee joint of an eight-months' foetus. Both of these figures show a blood vessel cut longitudinally in the center of the villus.

Lymphatics

The joint capsule is well supplied with lymphatics which have until recently been demonstrated by the injection of dyes into the articular cavity. Although Landzert (1867) and other authors of his time referred to lymphatic vessels in synovial capsules, Tillmanns (1876) was probably the first to illustrate and describe this lymphatic plexus. By the injection of dyes into the joint cavity, he demonstrated lymphatic plexuses in the articular capsule, some of which he found immediately subjacent to inner lining cells which he called endothelium.

Recently new methods have been introduced for the demonstration of lymphatics in articular capsules. Magnus (1923) demonstrated them by India ink and hydrogen peroxid injections and Fisher (1923) by colloidal silver injections. Zalewski (1928) injected a colored mixture into the articular capsule, using the method of Gerota, and demonstrated two lymphatic plexuses, external and internal, which were found to communicate with each other, forming a closed system not communicating with the joint cavity by openings or so called "stomata".

By the interaction of ferric ammonium sulphate and potassium ferrocyanide solutions, I have been able to demonstrate the lymphatic vessels in the synovial capsules from the knee joints of rabbits and guinea-pigs. About one cubic centimeter of a two-per-cent. solution of ferric ammonium sulphate was first injected into the joint cavity, and about thirty or forty minutes later this was followed by the injection of one cubic centimeter of a two-per-cent. solution of potassium ferrocyanide, the formation of Prussian blue taking place in the lymphatic vessels. On examining the capsule in a fresh condition under the microscope a rich lymphatic plexus was clearly visible, some of the vessels extending quite close to the synovial surface.

I have used this method with marked success in demonstrating lymphatics in the diaphragm of the mouse. The lymphatic plexus containing Prussian blue presented a marked contrast to the plexus of blood capillaries.

Nerves and Nerve Endings

Nerves were demonstrated in articular capsules as early as 1873 when Nicoladoni described a plexus of pale nerve fibrils in rabbits. Rauber

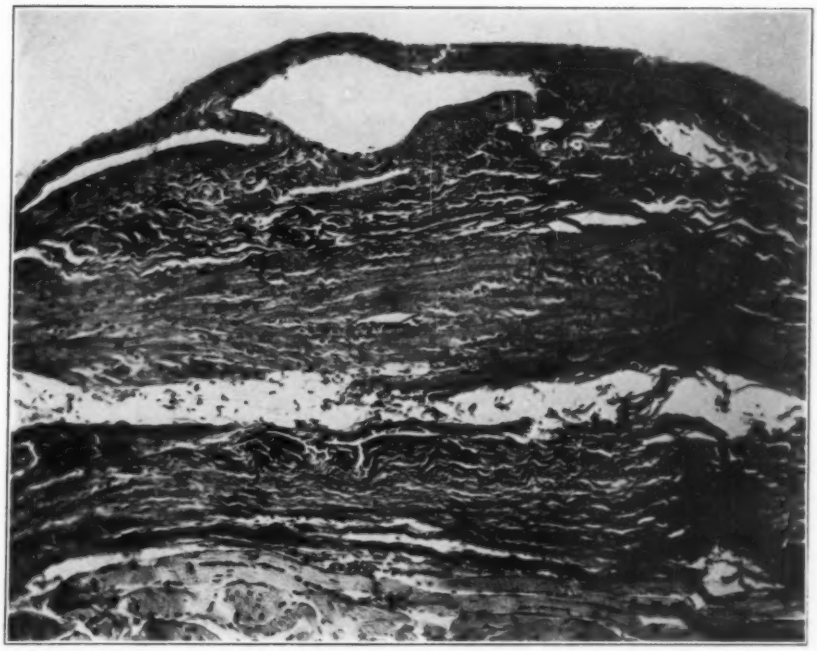

FIG. 16

Cross section of the capsule from the knee joint of a guinea-pig, showing two large blood vessels near synovial surface. The synovial surface cells do not differ markedly from the subjacent cells. × 70.

(1874) and Krause (1874) described nerves terminating in pacinian bodies and end bulbs. These end organs were named by Krause "*Gelenknervenkörperchen*". Hagen-Torn (1882) found nerves forming a network terminating in end organs in the articular capsules from cats, dogs, and guinea-pigs. Fisher (1923) observed two delicate nerve plexuses in joint capsules which were found to communicate with each other by nerve fibrils.

A good demonstration of nerve trunks can be obtained by the use of gold chlorid solutions. For the demonstration of nerves in synovial capsules of rabbits, I have used the Cajal method and the Ranson (1914) modification of the Cajal method. In such preparations a plexus of nerves was observed in the connective tissue of the capsule, which was found to communicate with a very fine plexus immediately subjacent to the synovial surface cells.

Blood Vessels

The joint capsule is very vascular, the capillaries ramifying as they pass inward, and on reaching the inner free surface they lie parallel to it for some distance, pursuing a tortuous course, and anastomosing freely with neighboring vessels. The capillaries do not lie free in the joint cavity, as was maintained by Hueter but later disproved by Hammar, Hofbauer, and others. Although lying quite close to the surface, they are always

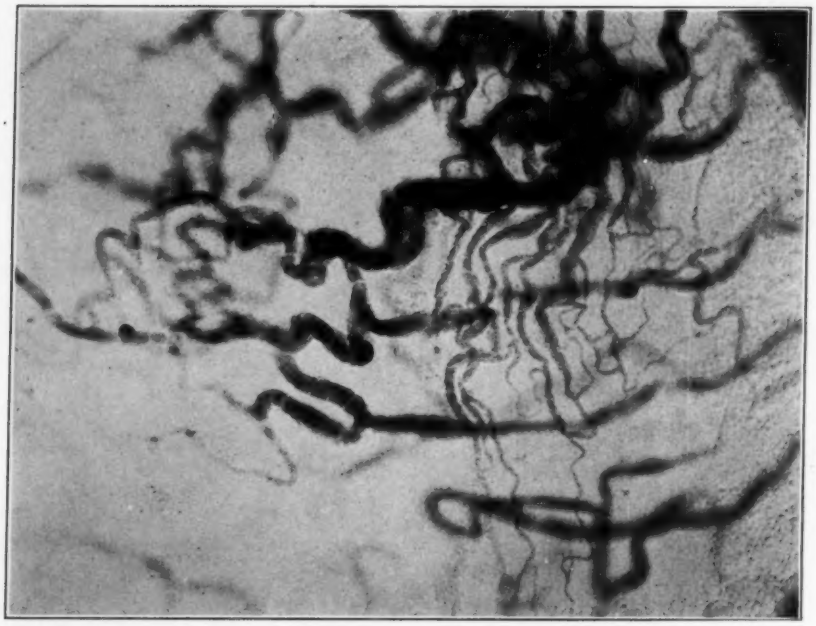

FIG. 17

The synovial surface from the capsule of the knee joint of a guinea-pig, two and a half hours after the injection of 0.25 c.c. of a colloidal silver solution, showing the rich anastomosis of blood capillaries. × 50.

covered by one or more layers of connective-tissue cells as illustrated in Figure 16, which is a cross section of the capsule from the knee joint of a guinea-pig.

In demonstrating these capillaries, two methods can be adopted: a colored mass can be injected into the aorta, or certain irritating substances can be injected into the joint cavity. By injecting twenty-five one-hundredths cubic centimeters of a colloidal silver solution into the knee joints of anaesthetized guinea-pigs, and killing the animals two and a half hours later, I was able to demonstrate a rich capillary plexus present near the inner surface (Fig. 17).

Although it appears in many places like vascular tufts, these only remotely suggest the glomerular tufts in the kidney, as stated by Hofbauer. At the cartilaginous margins, the vessels pass for a short distance into the cartilage, where they stop abruptly and emerge again, thus forming loops. This capillary plexus of the cartilaginous margin was first described by Hunter (1743) in the following words: "All round the neck of the bone there are a great number of arteries and veins, which ramify into smaller branches, and communicate with one another by frequent anastamoses like those of the mesentery. This might be called the circulosus articuli vasculosus, the vascular border of the joint." The researches of Toynbee (1841) led him to believe that as a result of pressure exerted on the articular cartilage,

the vessels recede towards the periphery, so that in adult life they are found only at the margin of cartilages. Hofbauer emphasized the tortuosity of this rich vascular plexus in relation to diseases of joints.

Fat Cells in Articular Capsules

The amount of fat varies in different portions of the capsule; in some places it is massed into fat pads, while in other places only a few fat cells are present. By using the freezing microtome and staining the sections with osmic acid and Sudan III, fat cells can be demonstrated in the articular capsule. In these sections, fat cells are usually aggregated in small groups situated for the most part near the synovial surface, but they are often found in the larger synovial villi.

II. FUNCTION

Boyd (1925) declared, "Our knowledge regarding the physiology of joints is still very limited, for a joint is a structure which does not attract the physiological investigator". Unfortunately this statement is only too true, for little is known of the origin of the synovial fluid, the function of the so called synovial membrane, the mechanism involved in the removal or lysis of both normal and abnormal particles from the joint cavity, and lastly the exact etiology of joint diseases.

Meyer (1924) wrote, "Ever since synovia was studied carefully, it has been known that it contains small fragments of cartilage and that the quantity of these increases with use", and Key (1928) maintains that "the current opinion seems to be that the synovial fluid contains only the debris cast off from the joint surfaces, and occasional leucocytes or lymphocytes". How does the joint dispose of these cartilaginous fragments and foreign bodies introduced into the joint cavity? Where does the synovial fluid originate? Fisher (1923) believes that mucin gains entrance to the joint cavity in three ways: from the surface cells, from the deeper cells which discharge it into villi from whence it is squeezed out into the joint, and from detached surface cells which undergo a mucinous transformation.

Attempts have been made by some investigators to solve some of these problems by determining the mechanism involved in the removal of certain dyes, carbon particles, and other foreign substances from joint cavities after these had been previously introduced, hoping thereby to gain some conception of the functioning of the normal joint.

In spite of these investigations, the words of Bichat, written over a century ago, are probably as true today as they were then: *"Aucune partie de la physiologie des os n'abonde plus en hypothèses et moins en découvertes, que l'histoire du system synovial. Beaucoup de dissertations et peu de faits; longue série de principles supposés; court ensemble de preuves."*

Material and Methods

Rabbits and guinea-pigs were the only animals used in this part of the investigation. Carbon particles and other foreign substances were

injected into joint cavities and the mechanism of their removal studied. Substances opaque to the roentgen rays were injected into the knee joints of rabbits and the rate and manner of their disappearance from the joints was recorded on a series of skiagrams. Tibiotarsal joint immobilization with plaster-of-Paris casts was attempted on rabbits, and the effect of this was noted on the amount of synovial fluid in the joint and upon the joint capsule.

Disappearance of Carbon Particles from Joint Cavities

Carbon particles, in the form of India ink, have been used in investigations of this nature by Mosengeil (1875), Braun (1894), Kroh (1908), and Key (1926). Braun studied most of his preparations a few hours after injection and found that the leucocytes and fixed cells retained the injected material. Kroh, in opposition to the work of Mosengeil, found that the whole of the joint cavity was darkly impregnated after injecting India ink and washing out the joint. Key, working on rabbits, found that most of the carbon was removed from the joint cavity by the action of macrophages and leucocytes, although a small amount of free carbon passed through the intact synovial surface, some of it being carried to the neighboring lymph nodes, but the greater part remaining around the loose tissues of the joint.

In my investigations Higgins' India ink was diluted with ten times its volume of distilled water, filtered and sterilized, and then injected into the knee joints of adult guinea-pigs, under ether anaesthesia, under aseptic conditions. About two-tenths cubic centimeters was injected into the right knee joint and the animals killed at intervals of from one-half hour to sixty-one days after the injection. Portions of the joint capsules were removed, fixed, hardened, and imbedded in the usual manner.

Observations

On examining the joint thirty minutes subsequent to the injection, most of the India ink was still present within the joint cavity but some of the granules were contained within the superficial synovial cells. After one day, the carbon particles were also found in the deeper parts of the articular capsule. The inguinal lymph nodes contained carbon granules. In a joint examined on the third day after the injection there was a marked inflammatory exudate within the joint cavity, the reaction being more marked in this instance than in any of the subsequent joints examined. A large inflammatory mass was present adhering to the lateral wall of the capsule where most of the carbon was engulfed by phagocytic cells. More carbon was present in the inner superficial cells of the capsule than in the subjacent connective tissue, an observation which was recorded by Key on articular capsules of rabbits examined five days after injection. A large fibrinous black mass was present in one portion of the deeper part of the capsule which might have been due to its rupture at that point.

Fourteen days after injection, the joint cavity contained no free carbon but large amounts were still present in the joint capsule, although some of it

was deposited in the inguinal and lumbar lymph nodes, which were black with carbon pigment.

At the end of forty-nine days, fewer carbon particles were to be found in the capsule. A similar condition was found at the end of sixty-one days. In this latter case, although the surface cells contained small amounts of carbon, most of it was observed in the deeper portions of the capsule. Key, on the contrary, found a large amount of carbon present in the surface cells after a period of one hundred and four days.

From these observations it is evident that although a large amount of these carbon granules is deposited in the inguinal and lumbar lymph nodes, a considerable quantity is still to be found in the connective tissue of the joint capsule itself. The question now arises as to the mode of disappearance of these carbon particles from joint cavities. Some of them gained entrance to the rich lymphatic plexuses of the capsules and were conveyed to the lymph nodes. Shipley and Cunningham (1916) found that fine India ink granules could pass directly into blood vessels, which may account for a small portion of the carbon particles leaving the joint cavity by way of the rich articular capillary plexus. Wandering phagocytic cells engulfed large quantities of the carbon and thus removed it from the joint cavity, a phenomenon most marked during the first two weeks. These cells are probably responsible for the removal of the greater part of the carbon from the joint cavity. Some of these particles gained the deeper part of the capsule by passing through or between the surface cells, where they remained for a period of sixty-one days.

Absorption of Iron from Joint Cavities

If a ferric-ammonium-sulphate solution is injected into a joint cavity and is immediately followed by the injection of potassium-ferrocyanid solution, the well known deep blue precipitate, Prussian blue, is produced. If the two injections are made at four-hour intervals, no precipitate occurs. A relatively simple qualitative test for iron thus furnished a means for determining its rate of disappearance from joint cavities.

Four rabbits from the same litter were taken, and under ether anaesthesia, one cubic centimeter of a two-per-cent. solution of ferric ammonium sulphate was injected into the right knee joint of each. In order to avoid leakage through the puncture hole, the needle was pushed through the patellar ligament into the joint cavity, between the patella and the femur. At intervals of fifteen minutes, forty minutes, one hour, and four hours, the animals were anaesthetized again and one cubic centimeter of a two-per-cent. solution of potassium ferrocyanid was injected, and the animals killed immediately thereafter. At the end of fifteen minutes, a marked blue color was present in the joint cavity, but at the end of forty minutes no reaction occurred in the joint cavity, but a microscopic examination of the capsule revealed this blue color in the lymphatics. The same was true in the other two cases. Further experimentation on guinea-pigs and rabbits showed that the iron had completely disappeared in thirty minutes.

This simple experiment illustrates the fact that certain substances disappear rapidly from joint cavities, in marked contrast to the disappearance of certain radiopaque substances where an oil is used as a menstruum. Such an element is iodin in the form of iodized oil, and the manner and rate of its disappearance from the joint cavity were studied radiographically.

FIG. 18

Skiagram of the knee joint of Rabbit I, taken immediately after the injection of 0.5 c.c. lipiodol into the joint cavity.

Absorption of Iodized Oil from Joint Cavities

Carbon particles and other foreign substances, when injected into joint cavities, find their way out by means of the lymphatic vessels, and this in a large measure is due to the inflammatory action which usually occurs. The route taken by non-irritating substances in exit from the joint cavity presents another problem. A substance possessing this property is lipiodol, or iodized oil, which is forty per cent. metallic iodin in poppy-seed oil. It was introduced by Sicard and Forestier (1921) as a contrast medium for radiographic work, and is similar in composition to the German preparation iodipin.

In this study, four rabbits about two to three months old were selected, and under ether anaesthesia five-tenths cubic centimeters of lipiodol was injected under aseptic conditions into one knee joint of each animal. Skiagrams were taken at once and at intervals of four, twenty-three, forty-seven, seventy-two, and ninety-six hours. At the end of sixty-six hours Rabbit III was killed and the joint capsule and surrounding tissues were examined. Seventy-six hours after the injection of the lipiodol, Rabbits I and II were killed and examined in the same way. Rabbit IV was killed and examined at the end of ninety-eight hours.

The skiagram taken at the end of four hours showed no change from the previous one (Fig. 18), which was taken immediately after the injection of the lipiodol, and even at the end of twenty-three hours (Fig. 19), most of

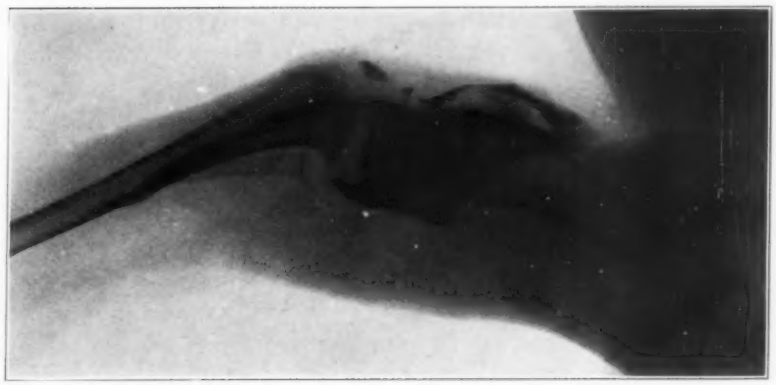

FIG. 19

Skiagram of the knee joint of Rabbit I, taken twenty-three hours after the injection of 0.5 c.c. lipiodol into the joint cavity.

the substance was still in the joint cavity, though a small amount was distributed along the leg.

Forty-seven hours after the injection of the lipiodol, the skiagram (Fig. 20) showed most of the substance distributed around the tibiotarsal joint, although a small amount was distributed between this joint and the knee joint, and some of it was still present in the joint cavity of the knee. Judging from the skiagrams (Figs. 21 and 22), most of the iodized oil gravitated into the more dependent portions of the limb, the greatest amount being found in the region of the tibiotarsal joint, although in the case of Rabbit IV a part had moved towards the hip joint (Fig. 23). This coincides with observations which have been made in connection with the injection of lipiodol into the lungs for the purpose of diagnosing pulmonary diseases, where the oil has been found in the base of the lungs six weeks after injection.

Judging from the skiagrams, the mode of disappearance of iodized oil from joint cavities offered a marked contrast to the disappearance of carbon particles and other foreign substances. The rôle of the lymphatics of the

FIG. 20

Skiagram of the knee joint of Rabbit II, taken forty-seven hours after the injection of 0.5 c.c. lipiodol into the joint cavity.

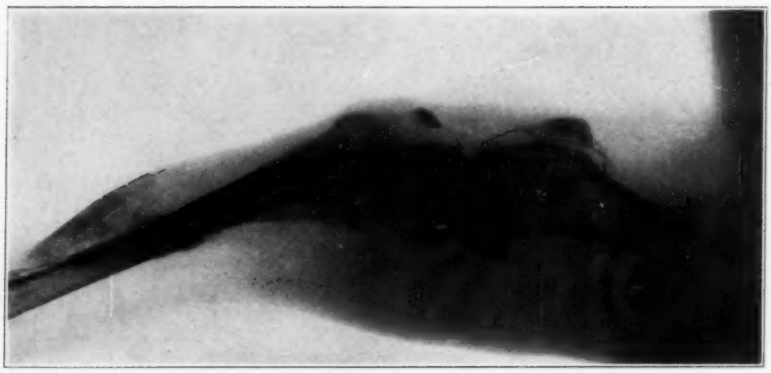

FIG. 21

Skiagram of the knee joint of Rabbit I, taken seventy-two hours after the injection of 0.5 c.c. lipiodol into the joint cavity.

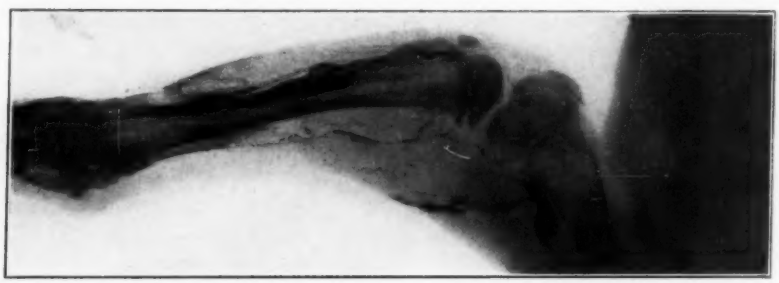

FIG. 22

Skiagram of the knee joint of Rabbit IV, taken seventy-two hours after the injection of 0.5 c.c. lipiodol into the joint cavity.

FIG. 23

Skiagram of the knee joint of Rabbit IV, taken ninety-six hours after the injection of 0.5 c.c. lipiodol into the joint cavity.

capsule in this process was evidently a minor one, for the whole capsular surface appeared to be involved in the process to a greater or less extent. A large amount of the oil probably was transmitted through the capsular surface at all points, most probably due to pressure changes within the articular cavity as a result of movements of the joint. The actual process involved in its passage through the articular capsule could only be partly ascertained by study of the skiagrams, therefore an examination of the tissues was made.

None of the joints injected showed any indication of infection. On opening the knee joint sixty-six hours after the injection of the iodized oil, the inner portion of the capsule was observed to be slightly oedematous and of a brownish-yellow color. A microscopic examination of a frozen section revealed the presence of small droplets of the oil in the connective tissue of the capsule for the most part near and on its inner surface. A similar condition was observed in the capsules of animals killed seventy-six hours after injection. In the animal killed ninety-eight hours after injection, most of the oil had disappeared from the capsule, although some droplets were still present near its inner surface. The significance of this observation will be discussed subsequently.

The value of iodipin in the diagnosis of congenital dislocation of the hip has been demonstrated by Sievers (1927). This author has raised the question of its use as a therapeutic measure in diseases of the joint, particularly arthritis and rheumatism. The fact that it remains in the joint for long periods of time without apparent injury to the tissues appears to make it a very suitable agent for the diagnosis and treatment of joint diseases. Kobes and Militzer (1928) demonstrated on a large number of children that the intra-articular injection of iodipin produced a marked leucocytosis in two hours. However, twenty-four hours later this was again normal. A marked increase in lymphocytes was found to extend over a period of one month; and on this account they considered that the treatment of joint tuberculosis with iodized oil was of special benefit.

After leaving the joint cavity and gravitating to the most dependent parts of the body, the ultimate elimination of the iodin is a problem for the chemist and does not concern us here. Its removal from the body is slow, for Boulan (1922) proved by skiagrams that the intramuscular injection of iodized oil gave shadows that could be distinguished at the end of three and a half years, and Kobes and Militzer (1928) found iodin present in the urine of a child four hundred and ten days after injection.

The fact that lipiodol is present in the joint capsule of rabbits after a period of ninety-eight hours demonstrates its very slow disappearance from the joint cavity, and serves to indicate that the length of time that the iodin would act when used as a therapeutic agent is as yet not definitely proved and offers a fruitful field for further investigation.

Joint Immobilization

What is the effect, if any, on the articular capsule of putting the joint at rest? In attempting to answer this question, five rabbits about four months of age were anaesthetized and the right tibiotarsal joints were immobilized by the application of plaster casts. The knee joint, although a larger joint, is not as well adapted for this procedure as the tibiotarsal joint. Great care was necessary in the application of these casts since too great pressure at any point might have produced gangrene of the part. A daily inspection was made to guard against this mishap. Although every precaution was taken, absolute immobilization was, of course, not possible, and some slight degree of movement at the joint was unavoidable.

At intervals of seven, thirteen, twenty-four, thirty-nine, and fifty-three days, the animals were killed and the anterior portions of the capsules from both tibiotarsal joints excised, placed in Zenker's solution, hardened, embedded, and cut in the usual manner. The sections were stained with hematoxylin and counterstained with eosin or van Gieson's.

At the end of a week, no structural differences were noted between the two joint capsules, and the synovial fluid appeared equal in amount. After thirteen days, the only difference noticed was a slight irregularity in contour of the synovial surface of the capsule; in places it appeared to be gathered into folds with crypt-like spaces in between.

At the end of twenty-four days, the synovial fluid was noticeably less in the immobilized joint than in the normal, but the only change noticed in the capsule was a slight decrease in vascularity. A condition somewhat similar was observed at the end of thirty-nine days though in the case examined there happened to be less fat in the capsule. The synovial fluid at the end of fifty-three days was markedly less in the immobilized joint than in the normal. The nuclei of the surface cells stained poorly, probably due to degeneration, and synovial villi with pointed extremities were numerous.

No infection occurred in or around the joints immobilized, and all the animals were in good condition when killed. There was, however, considerable atrophy of the muscles of the leg. That the synovial fluid in the joint cavity was diminished in quantity as a result of prolonged immobilization of the joint, was to be expected. A smaller quantity may have been needed for the proper lubrication of the joint and less is formed under conditions of rest. The pressure produced by the cast may account for the increased number of villi, although no definite conclusions can be drawn from the limited data.

From these observations it is evident that no marked structural changes occur in the joint capsule as a result of joint immobilization for such brief periods. However, there is an appreciable decrease in the quantity of the synovial fluid present in the joint cavity as compared to the normal.

III. CONCLUSIONS

1. The inner surface of articular capsules is not formed by a distinct membrane, but by connective tissue modified as the synovial surface is reached. The cells here are more closely packed and the nuclei exhibit peculiar staining characteristics, but that does not seem to justify the use of the term membrane.

2. The superficial synovial cells are not uniform in size or shape, some being quite small and round while others are large with branching processes. This type of cell is not confined to the surface.

3. Synovial villi vary greatly in size and shape and are composed of connective tissue resembling the part of the capsule from which they arise.

4. An excellent demonstration of variation in cell outlines on the synovial surfaces of articular capsules can be obtained by the use of silver-impregnation methods. The intercellular substance is found to be abundant, in contrast to that of the pleura and peritoneum; and the apparent cell outlines are much more irregular and do not resemble those of an endothelial or mesothelial layer.

5. The presence of "stomata" in articular capsules is not confirmed.

6. Carbon particles, when injected into the knee joints of guinea-pigs, evoke an inflammatory exudate in the joint cavity, most marked on the third day after injection. Some of these carbon particles are taken up by the lymphatic vessels and are deposited in the inguinal and lumbar nodes, while others are removed from the joint cavity by the action of phagocytic cells, some of which gain the lymphatic vessels while others remain in the subsynovial connective tissue for an indefinite period.

7. Iron, in the form of ferric ammonium sulphate, disappears from joint cavities within thirty minutes after injection by way of the lymphatics.

8. Iodin in the form of lipiodol diffuses slowly through the joint capsule, a period of at least four days being required for its complete removal, as judged by skiagrams.

9. Immobilization of the tibiotarsal joints in rabbits over fifty-three days produced no marked structural changes in the joint capsule, but the amount of synovial fluid was considerably less.

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DISLOCATION OF THE KNEE

Report of Four Cases

BY JOSEPH I. MITCHELL, M.D., F.A.C.S., MEMPHIS, TENN.

Traumatic dislocation of the knee, not associated with fracture of one of the constituent bones, is uncommon in comparison with other lesions of this joint. The dislocation may be complete or incomplete and may be caused by direct or indirect violence. A sudden force against the leg may dislocate the tibia or a similar force against the thigh will displace the femur. Indirect forces act by hyperextension or rotation of the knee while the leg is fixed, as in the lunging forward of the body when stepping into a hole, the sudden dropping of an elevator, or the twisting of the leg in a moving wheel or belt. According to Cotton[1], the tibia may be displaced in one of four directions: anteriorly, posteriorly, laterally, or medially; anterior dislocation being the most common.

Pathology: The essential lesion consists of an extensive laceration of the articular capsule and the ligaments about the joint. In anterior dislocations all the ligaments, except the patellar tendon, may be partially lacerated or completely severed; the anterior crucial ligament is always ruptured; the posterior crucial ligament is usually severed as well; the hamstring tendons may be avulsed and are always stretched; portions of the lateral ligaments may remain intact; and the semilunar cartilages may be fractured or displaced. Penetration of the skin in the popliteal space by the lower end of the femur is a serious complication. Injuries to the popliteal nerves, particularly the common peroneal nerve, and to the blood vessels are not unusual and gangrene may be inevitable in those with impairment of the circulation, making amputation above the knee necessary.

In posterior dislocations the lower extremity of the femur can be palpated anteriorly and the upper extremity of the tibia posteriorly in the popliteal space. The patella may be displaced medially or laterally, or may lie in the notch between the femoral condyles. The posterior crucial ligament is always ruptured in posterior dislocations. The lateral dislocations are associated chiefly with rupture of the lateral ligaments, although other structures may be lacerated in addition.

Treatment: Reduction in all types is accomplished easily, as a rule, by manipulation and traction. In the anterior dislocations, however, the knee joint should not be hyperextended further, as this would place greater tension upon the already overstretched blood vessels and nerves. After reduction the tendency toward redislocation is prevented by applying a gutter splint or a cast which conforms to the shape of the leg, with the knee slightly flexed. Continuous traction should be avoided, as the extensively lacerated ligaments may become permanently elongated, thus inducing an unstable joint. At the end of four to six weeks the splint or cast is removed and the patient is given a brace with a joint at the knee, so constructed as to permit no lateral play, but a gradual increase in the range

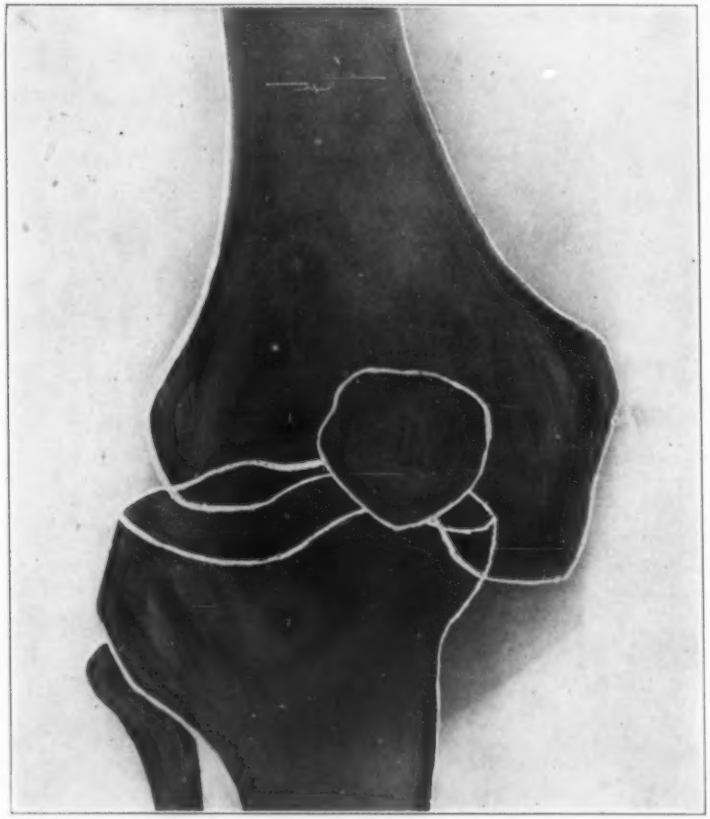


FIG. 1

Case 1. Anteroposterior roentgenogram showing overlapping of bones and medial displacement of tibia on femur.

FIG. 2

Same as Fig. 1—lateral view. Posterior dislocation of tibia on femur.

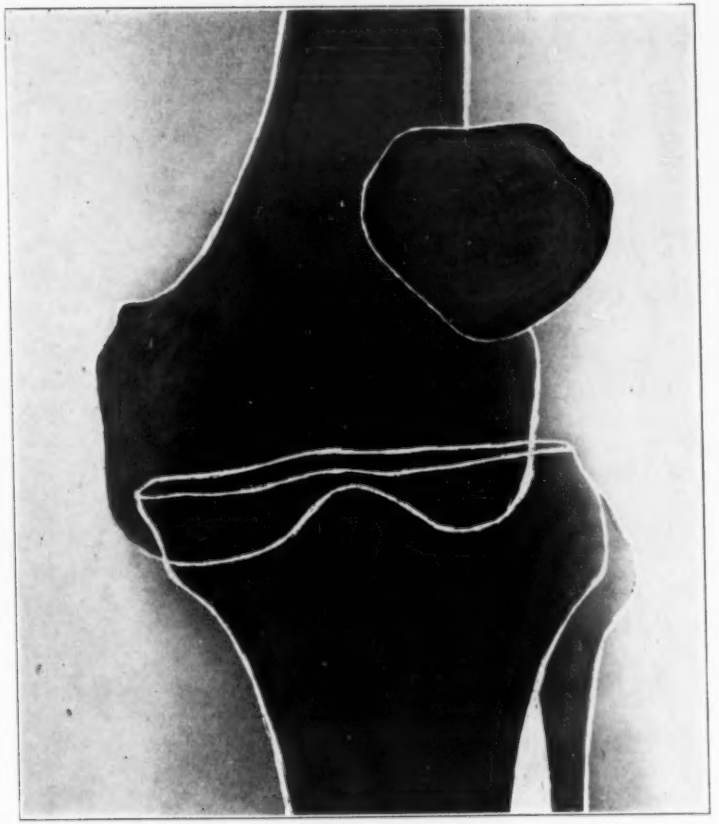


FIG. 3

Case 2. Anteroposterior roentgenogram showing complete anterior dislocation of tibia on femur.

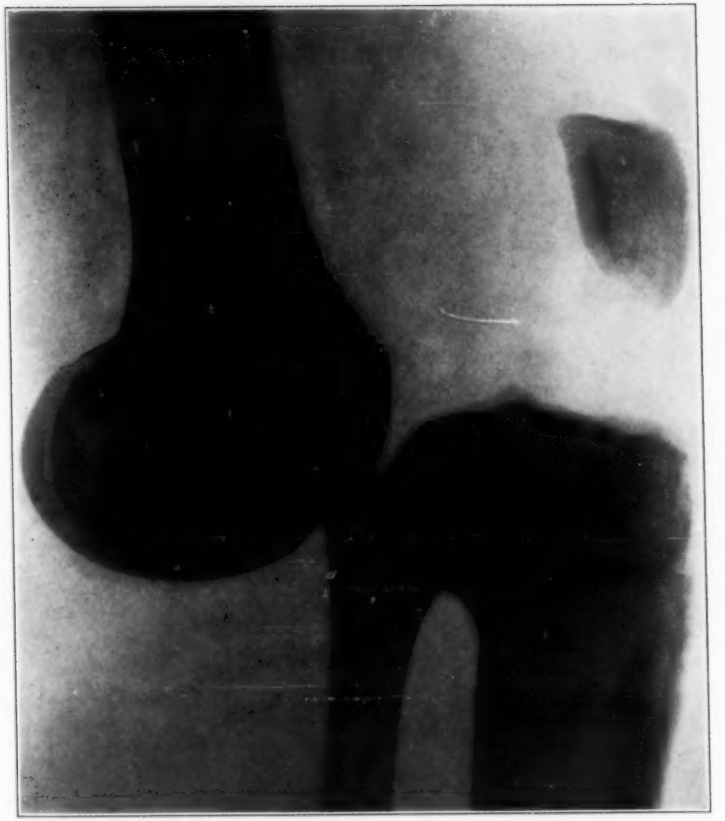


FIG. 4

Same as Fig. 3—lateral view.

of flexion. Muscular action to restore function should be cultivated gradually by physiotherapy, or by teaching the patient a systematic method by which active and passive movements can be made.

CASE REPORTS

CASE 1. A white male, aged forty-six, was first seen December 23, 1926. He presented an unreduced backward dislocation of the left tibia on the femur. The injury had been sustained three months previously, when the horse he was riding was struck by an automobile. The car wheel passed over the patient's left leg, crushing the knee, and causing an extensive lacerated wound on the outer side of the calf of the leg. The wound was sutured and dressed by his local physician, but no attempt was made to reduce the deformity of the knee. The patient remained in bed one month, and then was able to walk on crutches.

The examination showed the left knee held partially flexed, and there was three-fourths of an inch shortening of the leg. The tibia was displaced posteriorly and laterally under the condyles of the femur, and could be palpated in the popliteal space. The patella was depressed into the intercondylar notch of the femur, and was fixed by adhesions. Active and passive movements were limited to a range between 135 degrees extension and 95 degrees flexion. There was a healed scar on the outer surface of the leg. The dorsal extensor muscles of the foot were paralyzed, causing a foot-drop, and there was loss of sensation over the outer aspect of the foot and leg, corresponding to the distribution of the superficial peroneal nerve. The roentgenograms of the knee demonstrated an almost complete backward dislocation of the tibia at the knee. The tibia was also partially dislocated laterally. All bones showed a moderate amount of osteoporosis, but there was no evidence of fracture.

The dislocation of the knee was reduced by an open operation. A long incision medial to the quadriceps tendon was made, the patella was retracted laterally, and the joint exposed. There was a small amount of reddish brown synovial fluid in the joint cavity. The articular cartilages were yellow in color from absorption of the blood pigments, but were not eroded. The internal semilunar cartilage had been ruptured, and was so embedded in scar tissue as not to be identified. The external semilunar cartilage was also fractured at its anterior extremity and displaced medially. Both crucial ligaments had been ruptured. The intercondylar notch of the femur was filled by a dense mass of scar tissue extending to and adherent to the posterior capsule of the joint, and to the head of the fibula. The internal lateral ligament was ruptured, but the external lateral ligament was intact. The mass of fibrous tissue, including the semilunar cartilages and the crucial ligaments, was excised. The posterior capsule was divided and the posterior surfaces of the tibia and femur were stripped subperiosteally for three inches. Reduction could then be accomplished, and the position maintained with the knee in full extension. Slight flexion, however, allowed redislocation of the tibia. The wound was closed in layers, and a plaster cast applied. The cast was worn for one month and was followed by a brace with motion at the knee, and a joint at the ankle to prevent foot-drop. When the patient was last seen, October 10, 1927, the knee was stable, in good weight-bearing alignment, and he could walk without support. Motion was being restored gradually.

CASE 2. A negro male, aged thirty-two, was admitted on the orthopaedic service of the Memphis General Hospital, December 31, 1927. He had been struck by an automobile, which passed over his left leg at the knee. The contour of the knee was greatly distorted, the tibia being displaced forward, and the condyles of the femur projecting into the popliteal space; the patella was palpable, high on the thigh. The leg was held extended, and attempts to flex or hyperextend the knee were unsuccessful. Lateral movement was free in both directions, but caused great pain. The roentgenogram showed a forward dislocation of the tibia on the femur. There were no fractures.

The dislocation was reduced immediately by the intern in the receiving ward. Ether anaesthesia was used, and the reduction was accomplished by traction and slight

Same as Fig. 3—lateral view.

dislocation of tibia on femur.

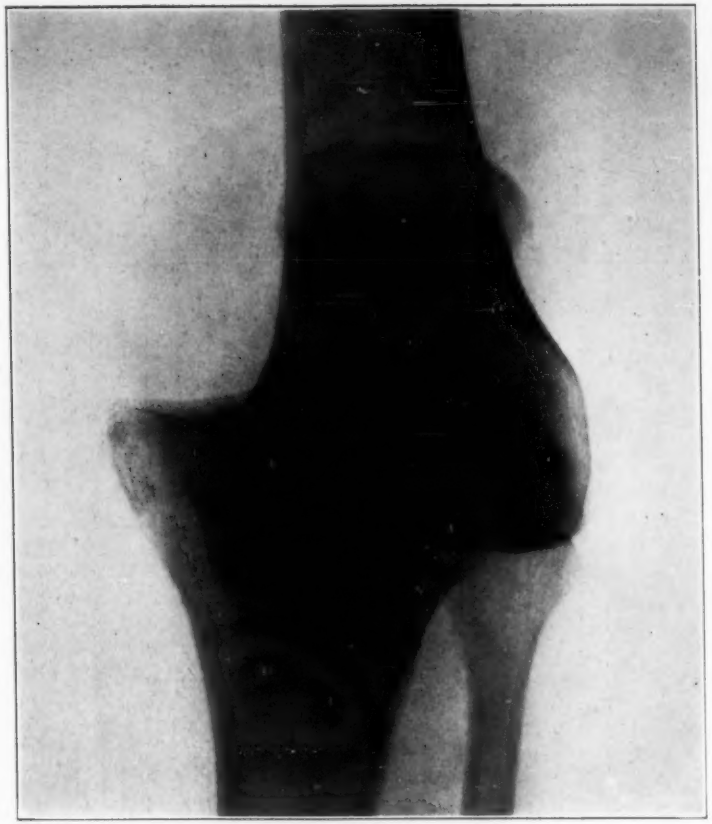


FIG. 5

Case 3. Anteroposterior roentgenogram showing complete anterior dislocation of tibia on femur with partial displacement to medial aspect.

FIG. 6

Same as Fig. 5—lateral view.

FIG. 7

Case 4. Anteroposterior roentgenogram showing narrowing of joint with subluxation of tibia anteriorly and medially.

FIG. 8

Same as Fig. 7—lateral view.

hyperextension. A splint was applied for retention, and, surprisingly, all pain and tenderness disappeared within twenty-four hours, and there was very little swelling. The muscles supplied by the peroneal nerve were paralyzed, but no sensory paralysis could be demonstrated. Two days later a cast was applied. This was worn for two weeks, and then removed daily for active motion. When last examined, three months later, the knee was stable, could be voluntarily extended, and there was about twenty degrees motion present. He walked with a cane, his greatest inconvenience being the persistent foot-drop.

CASE 3. The third case is reported through the courtesy of Dr. C. E. Warde, who kindly allowed the writer to examine the hospital record and the roentgenograms. A white woman, aged thirty-seven, was injured February 17, 1927. While walking along a board walk, her right foot caught under a loose plank, causing her to fall and wrench the right knee. The roentgenograms of the knee show a complete anterior dislocation of the tibia with a partial displacement toward the medial side. There were no fractures. Reduction was easily secured under gas anaesthesia, and the leg was immobilized in extension for several weeks. A brace was advised, but not obtained, as the patient's finances were limited. The functional result was excellent.

CASE 4. A white woman, aged thirty-one, was admitted to the hospital May 12, 1928. The previous day she had been struck by an automobile while walking along a country road. The force knocked her into a deep ditch and she sustained an injury to the left knee. There was severe pain in the joint and immediate disability, as she was unable to stand or walk. When admitted, the left knee was swollen and the joint distended by increased fluid. There was a large area of ecchymosis in the popliteal space and extending up on to the thigh. The knee was held extended in the anatomical position, but the tibia could be displaced forward on the femur, although it could not be entirely dislocated. There was also lateral instability, both to the medial and lateral aspects. All movements of the knee caused intense pain. Circulation, motion, and sensation of the lower leg and foot were normal. The provisional diagnosis, which was later confirmed by the roentgen ray, was: rupture of the anterior crucial ligament and both internal and external lateral ligaments with subluxation of the knee. The anteroposterior roentgenogram of the knee, which was taken while the joint was subluxated, showed an absence of the joint space and a slight displacement of the tibia medially. The lateral roentgenogram demonstrated anterior dislocation of the tibia on the femoral condyles. The patella was displaced upwards. There were no fractures visible. The leg was immobilized in a plaster cast with the knee slightly flexed. When the cast was removed, six weeks later, the joint seemed perfectly stable and the patient was allowed to begin weight-bearing with crutches.

COMMENT

The knee is involved in pathologic and traumatic processes more often than any of the other joints, but traumatic dislocations are seldom observed because separation of the articular surfaces requires the severance of many strong ligaments which can be produced only by great forces. Four cases of dislocation of the knee are reported, in three of which the tibia was displaced anteriorly and in one posteriorly. The functional result is often much better than would be anticipated. If reduction is secured early, the joint immobilized until healing of the soft tissues occurs, and the after-treatment carried out under proper supervision, the ruptured ligaments reunite and a practical range of motion is restored to the joint without pain or appreciably diminished endurance.

1. Cotton, Fredric J.: Dislocations and Joint Fractures. Ed. 2., Philadelphia, W. B. Saunders Co., p. 553, 1924.

SEBACEOUS CYST OF TERMINAL PHALANX OF THUMB

An Unusual Form of Bone Tumor

BY R. I. HARRIS, M.C., M.B., TORONTO

Associate Surgeon, Toronto General Hospital

The rarity and unusual nature of the bone tumor found justify the report of the following case.

Mr. T. H. G., an amateur golfer in the championship class, first discovered a disability of his left thumb five years ago. While grasping a golf club, he suddenly experienced severe pain in the ball of this thumb and this was accompanied by so much tenderness that he was unable to continue his golf. The tenderness persisted. There was no pain unless pressure was exerted upon the thumb. Four years ago examination of his thumb revealed nothing which might explain the tenderness, and two years later examination was again negative. X-rays were not taken at either of these examinations. The tenderness persisted and recently became greater and was accompanied by swelling. Examination at this time revealed the terminal phalanx of the thumb increased in size and very tender over palmar aspect.

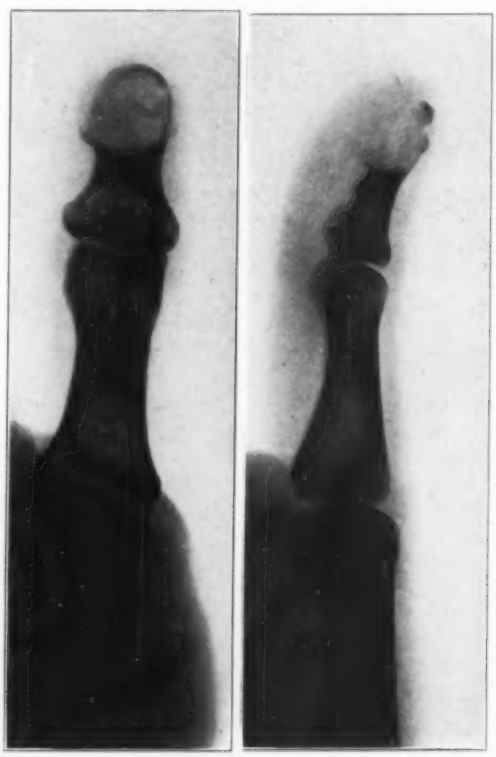


FIG. 1

Anteroposterior and lateral radiographs of the affected thumb.

Radiograph (Fig. 1) revealed a destructive lesion of the terminal phalanx of the thumb. The picture resembled a bone cyst. The distal half of the phalanx was expanded and its bony structure absorbed. Over the palmar aspect the cortex had entirely disappeared. Operation was advised under the diagnosis of bone cyst.

At operation the end of the phalanx was exposed by a transverse incision across the tip of the thumb close to and parallel with the edge of the nail. On elevating the soft tissues off the bone, the destructive agent was found to be a cyst with a dense wall of glistening white color. It peeled readily from its bony bed. The wound was closed by skin sutures after hemostasis.

Pathological examination of the operative specimen gave the following findings: The gross specimen consisted of a small cystic mass measuring one by five-tenths by

FIG. 2
Section of the wall of the cyst.

five-tenths centimeters. The outer surface was dense and glistening white in color while the contents of the specimen were grayish white, granular, and friable. Microscopic sections (Fig. 2) showed the wall of the cyst to be made up of a markedly flattened stratified epithelium clothed over its inner surface with a deep staining layer of keratin. There was no evidence of bone or of cartilage in the specimen. Diagnosis was epidermoid cyst.

The presence of an epidermoid cyst within a bone must be of rare occurrence. The writer has been unable to find any report of a similar case. Such a structure, so different in its derivation from osseous tissue, could not have arisen from bone cells *per se*. The only reasonable explanation of its presence is that it is an implantation cyst. At some distant period, a deep puncture wound of the end of the thumb must have carried epithelial cells into the phalanx, where they slowly multiplied and secreted sebum. Unfortunately no history of such an accident could be obtained. Apparently the earliest symptoms, five years ago, were due to fracture of the cortex overlying the cyst.

REPORT OF A CASE OF SUPERNUMERARY FOOT

BY LEO MAYER, M.D., *Attending Orthopaedic Surgeon, Hospital for Joint Diseases*
AND
DAVID SASHIN, M.D., *Frederic Brown Research Fellow*, NEW YORK, N. Y.

Although supernumerary toes are frequently seen, a supernumerary foot is so rare a congenital anomaly as to deserve report. In a search of the literature we have been unable to discover a similar case.

The patient, R. T., white female, age eight weeks, was admitted September 15, 1926, to the Hospital for Joint Diseases.

No other member of the family had a congenital deformity. The mother's pregnancy and parturition had been normal. The baby's general condition was excellent and there was nothing of medical interest in the physical examination except the peculiar left lower extremity. This is best understood by studying Figures 1 and 2, photographs of the left foot (or rather feet) from the dorsal and plantar aspects. These show that there are nine toes, four belonging to the mesial foot, five to the lateral foot. The lateral foot slightly overlaps the mesial foot's dorsal surface. This causes a plantar prominence of the mesial foot's little toe, and a dorsal prominence of the lateral foot's great toe. This lateral great toe is smaller than the mesial and is partly fused to the lateral second toe. There is no line of cleavage between the two feet, except just posterior to the toes, where for an inch the two feet can be separated. The heel, not clearly seen in the photographs, is almost twice as broad as that of the right foot. Both left feet are in an everted position and the mesial foot shows an abduction of the forefoot of about fifteen degrees.

FIG. 1

Left lower extremity viewed from below.

FIG. 2

Left lower extremity viewed from above.

FIG. 3
Roentgenogram of both feet.

FIG. 4
Photograph of the accessory foot subsequent to its removal.

FIG. 5
Roentgenogram of accessory foot subsequent to its removal.

FIG. 6

The foot at time of writing showing the scar along the outer aspect.

FIG. 7

The left foot at time of writing viewed from the sole.

FIG. 8

Photograph of patient standing.

FIG. 9
Roentgenogram of left foot at age of three years.

The roentgenogram illustrates the deformity still further (Fig. 3). It confirms the presence of nine left toes, each with its normal phalanges and corresponding metatarsal bones. The metatarsals of the lateral foot are thinner than those of the mesial and the fourth is fused to the fifth at its base. The ossification centers of the os calcis, astragalus, and cuboid show almost the same grade of development in all three feet. The astragalus of the mesial left foot articulates with the tibia; therefore it was easy to decide which of the two left feet to remove.

FIG. 10
Roentgenogram of left foot at age of three years.

Operation: The incision was so planned as to utilize the skin of the supernumerary lateral foot to cover over the denuded surface of the mesial foot. It ran along the dorsum and plantar surface of the lateral foot in a line with the third toe. The skin flaps were dissected away from the fascia until an indistinct plane of cleavage between the two feet could be identified. It was then easy, working from the forefoot backward, to split off the extra foot. The skin flaps were then trimmed so as to permit an accurate suture along the outer border of the mesial foot.

Description of specimen: The accessory foot measured seven and five-tenths centimeters in length and three centimeters at its greatest width (Figs. 4 and 5). On dissection it was possible to identify the os calcis, astragalus, and cuboid, each of which had a center of ossification corresponding to the shadow in the roentgenogram. The cuneiform bones and the scaphoid were entirely cartilaginous. Of the five metatarsals, the inner was broader and slightly larger than the four outer. The two outer were fused at their base.

The wound healed by primary intention and several weeks after the operation a plaster-of-Paris dressing was applied in an attempt to correct the planovalgus deformity noted before the operation. Despite the continuance of this form of treatment until the present time, a moderate degree of flat-foot persists (Figs. 6, 7, and 8). The patient walks without limp and when wearing shoes, no abnormality would be suspected. The latest roentgenogram shows normal outlines except for a shadow just distal and lateral to the cuboid (Figs. 9 and 10). This probably represents the base of the inner metatarsal bone of the accessory foot.

A CASE OF HEREDITARY RECURRENT DISLOCATION OF THE PATELLA

BY BEVERIDGE H. MOORE, M.D., CHICAGO, ILLINOIS

Recurrent dislocation of the patella is a rather rare condition. It is a well authenticated observation that it sometimes has an hereditary element. Weimuth about twenty years ago collected sixty-six cases. He classified them as follows: thirty-two were congenital, fourteen were traumatic, and twenty were of pathological origin,—that is an accompaniment of a severe knock-knee.

In the case reported here there is such an accurate hereditary history that it lends additional interest to the case and gives the reason for reporting it.

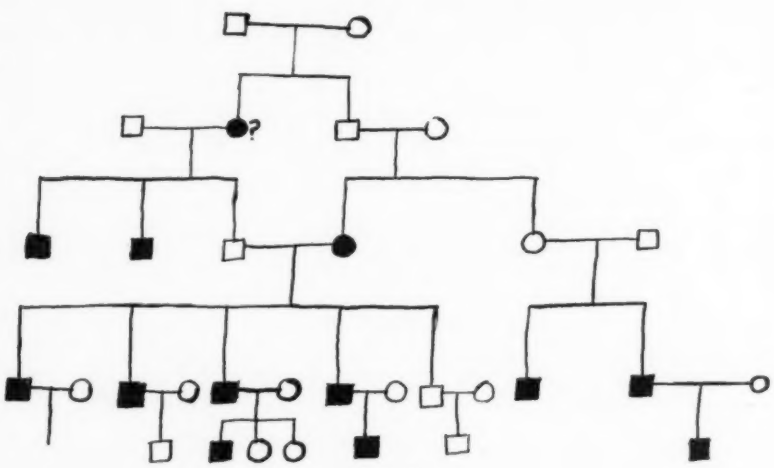


FIG. 1

Family tree of patient. The black squares and circles represent affected members.

E. S., a white male, nineteen years old, came to the orthopaedic clinic at Northwestern University Medical School, May 4, 1927, on account of occasional slipping of both patellae, resulting in a fall each time. The more immediate cause of his coming was that, while crossing a street, he found it necessary to run to avoid being struck by a bus. As he started to do so, his left patella slipped off and he fell. Fortunately the bus missed him, but it served to call the matter to his attention forcibly. His story was that the trouble began when he was nine or ten years old, and was not the result of any single definite accident. Both patellae had been dislocated, the left oftener than the right. Dislocation was very painful. He usually was able to reduce it himself, but it was always followed by a severe swelling which persisted for two or three weeks. As near as he could remember, it had happened fifteen or twenty times.

Examination: This showed no knock-knee, but rather a slight bow-leg. The muscles below the knee were very well developed. The thigh muscles were noticeably small in proportion to those below the knee, though they were by no means weak or

poorly developed. The patella itself was of normal size and while the muscles were relaxed was in normal relation to the knee joint. The knee joint capsule was rather lax, though the patellar and quadriceps tendons were not unduly long. The patella itself rode on the knee joint with the inner border distinctly higher than normal, — that is, the transverse axis of the patella was inclined to the transverse axis of the two condyles at approximately forty-five degrees. The inner and outer condylar ridges seemed to be in normal proportion. On contraction of the quadriceps muscle, the patella pulled decidedly to the outer side of the knee. The findings were the same on each knee.

The patient remarked that he had inherited the difficulty from his father, and on quizzing him a little more closely some interesting family history came to light. The patient's father has given this history in detail. The patient has no brothers, and two sisters are unaffected. His father has the same condition. He (the father) had four brothers who were affected in the same way, and one entirely unaffected. The one unaffected has one child who is not affected. One of the affected brothers has no children and one has one child about nine years old who is beginning to show trouble. The other affected brother has a child who does not show it. The father's mother had the condition; though of a large family she was the only one who showed it. Yet her sister had two sons and a grandson who had the difficulty in a serious way. The father's father did not have it though he did have two brothers who did have difficulty, though not seriously. The patient's grandfather and grandmother were first cousins. There was a family tradition that their mother had some difficulty of the sort, though this is not definite.

The patient had tried braces of various sorts without result; so operation was advised. The left knee was operated on first and the patella anchored to the internal condyle with a strip of fascia after the manner described by Gallie. The right knee was operated on three months later and the results have been quite satisfactory. At each operation it was noted that the internal head of the quadriceps muscle was very poorly developed. This was the only abnormality noticed. Inasmuch as this was the only defect noted, it would seem that it might have a causal relation to the difficulty, by producing an unbalanced muscle pull with the stronger outer head of the muscle pulling the patella in that direction. This underdevelopment might also account for the tilting of the patella noted. It might also account for the fact that the difficulty did not attract attention until the patient was nine or ten years of age. Since there is such a definite hereditary history in this case, it is probable that this peculiar development of the quadriceps is a transmissible characteristic which has led to the difficulty.

USE OF THE INTRAMEDULLARY BEEF-BONE GRAFT IN OPEN REDUCTIONS OF THE CLAVICLE

BY A. BROCKWAY, M.D., LOS ANGELES, CALIFORNIA

Resident Surgeon, Orthopaedic Hospital

Upon reading the various texts and articles on fractures of the clavicle one is left with the impression that good reduction of the clavicle is a relatively simple matter. The reason for this, undoubtedly, is that healing of this bone takes place rapidly and with a good functional shoulder even in the presence of considerable overlapping. That the treatment is not as satisfactory as desired is to be presumed from the fact that there are so many different kinds of dressings advocated for maintaining these fractures.

The usual deformity is a downward displacement of the distal fragment which overlaps in front of the medial fragment, because the lateral fragment is the unfixed fragment and because of the pull of gravity and the pull of the pectoralis muscle. It is difficult to obtain direct traction as in the case of fractures of the extremities, and one must rely mainly on levering the fragments over the oval contour of the chest wall. Even after reduction is obtained, there is no efficient way of maintaining proper elevation of the distal fragment, and relapses to the original deformity are common.

FIG. 1

Case 6922. After attempt at closed reduction.

FIG. 2
Case 6922. Eight months postoperative.

Of course it is true that a good functional result occurs even in the presence of considerable deformity, but everyone has seen short low shoulders after these fractures, often the source of dissatisfaction to the patient or his family; and in young women some consideration must be given to this cosmetic aspect of the problem. While no statistics are available these short low shoulders must be a factor in the production of a varying degree of scoliosis. Also these are days when juries are frequently looking at x-rays in malpractice suits. Many of these clavicles that have had a closed reduction, while they may be satisfactory to the surgeon, are not very complimentary when judged by a lay jury.

During the past two and a half years we have operated on eight of these fractures of the clavicle because of the poor position following closed reduction, using a small, intramedullary, beef-bone graft for internal fixation; and we have had good results in every case. The operation is usually very simple and if some care is given in the placing of the incision and its

FIG. 3
Case 6922. Eight months postoperative.

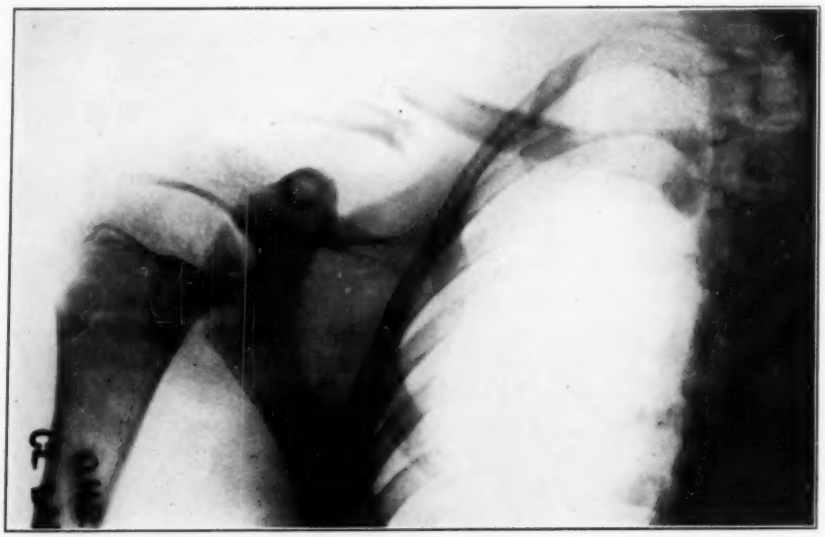


FIG. 4
Case 5651. After attempt at closed reduction.

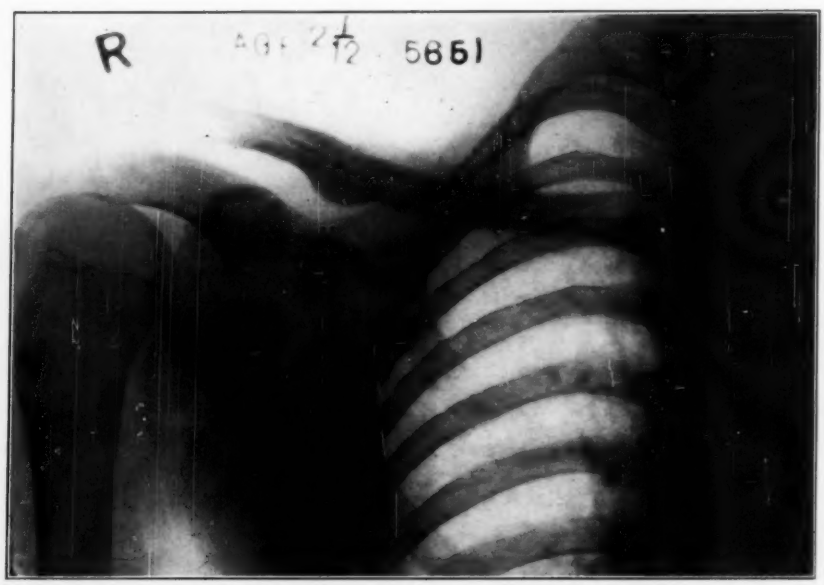


FIG. 5
Case 5651. Four months postoperative.

closure, the scar is very small and not unsightly. A short horizontal incision is made at the fracture site just below the clavicle, and the skin retracted upward; and the incision through the platysma muscle is made at a higher level directly over the bone. The fragments are then everted out of the wound and the medullary substance is reamed out of the distal end of the proximal fragment; and into this space is driven a small beef-bone peg for a distance of about one-half inch. Then by manipulation the projecting half of the graft is made to fit into a similar hole made for it in the distal fragment, thus securing an anatomical reposition with no tendency to angulation. In order to secure sufficient distraction of the fragments, it is sometimes necessary to use a spreader type of instrument similar in design to the spreader instrument used for spreading plaster casts. This instrument has a hole near the end of each blade large enough to let the bone graft pass through. The wound is closed by any method chosen by the operator designed to leave as little scar as possible.

In no case has the bone graft acted as a foreign body to cause delayed healing. Having strong internal fixation, the problem of external fixation is not an important matter. We have routinely used a posterior figure-of-eight plaster bandage well molded around the shoulders and extending about half way down the chest wall. This is applied while the patient is still asleep, and lying on a thin metal bar supported at either end by a wooden block, in order to facilitate wrapping on the plaster. The patient is up and walking in a few days, ready for discharge in a dressing that is very comfortable and that requires no adjustment. The forearm is carried in a sling, and the person has free use of his hand and partial use of the forearm. Plaster is removed in about three and a half weeks and if x-ray and clinical

FIG. 6

Case 5811. After attempt at closed reduction.

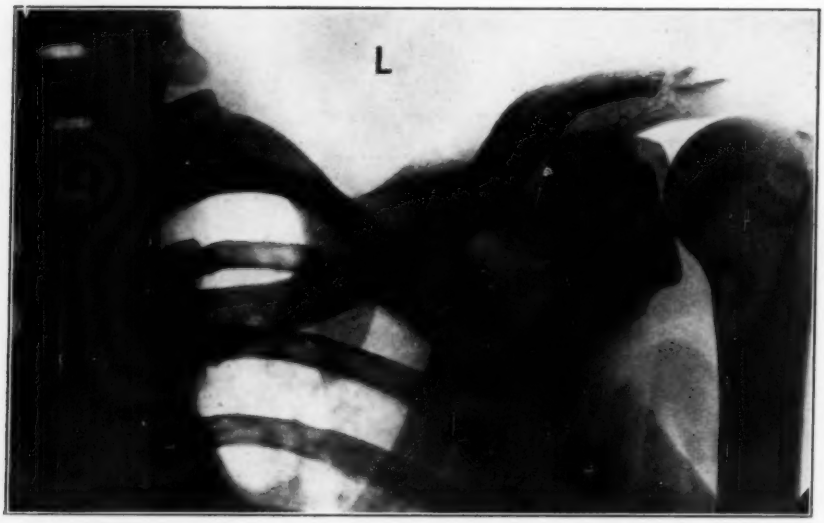


FIG. 7
Case 5811. Twenty months postoperative.

examination reveal good union, an ordinary sling is used as the only form of immobilization for another ten to fourteen days.

The accompanying photographs and x-rays will show the good contour of the shoulder with no shortening or drooping on the fractured side. It will also be interesting to note the degree of absorption of the foreign grafts at the different periods of time. In most cases there has been complete disintegration of the graft after a year's time.

CASE REPORTS

Case 6922. Age six years. Admitted June 1, 1929.

Closed reduction was attempted upon admission and x-rays following this attempt showed the distal fragment displaced downward about one-half inch and about one-quarter inch overlapping. X-rays taken August 12, 1929, nine weeks after open reduction, show no angulation at site of old fracture. The bone peg is still slightly visible but the graft outline is becoming more or less fused with the bone about it. Contour of the clavicle is unaltered but there is a little drooping of the shoulder due to a mild left dorsolumbar curve. There is a slight excess of callus, making the bone at the fracture site a little prominent. Open reduction was postponed for one week because of possible internal injuries received at the time of the accident. X-rays February 6, 1930, show complete absorption of graft. The scar is soft, the color of the skin, and not very noticeable. Rating A-4, E-4, F-4.

FIG. 8
Case 5811. Twenty months postoperative.

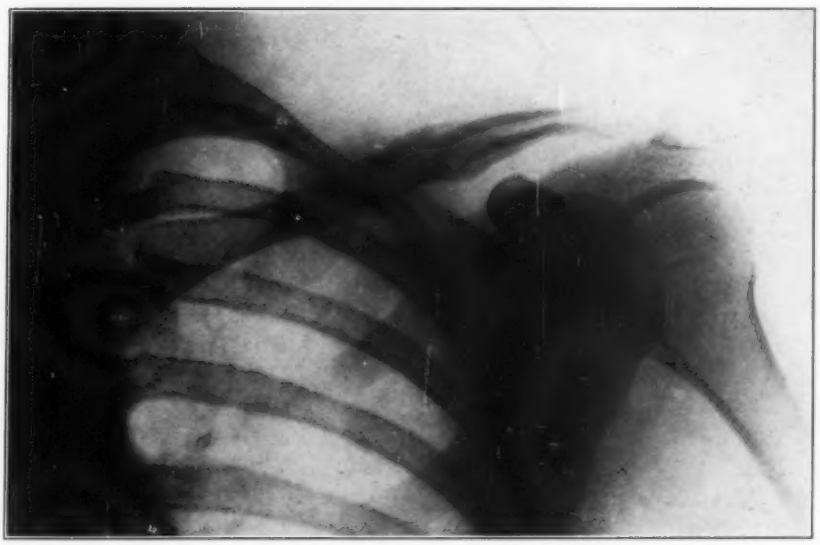


FIG. 9

Case 6649. After several attempts at closed reduction.

Case No. 5651. Age twelve years. Admitted April 27, 1928.

Two attempts at closed reduction were made without success. X-ray taken July 10, 1928, four months postoperative, shows anatomical contour of the right clavicle. Excess callus is seen along the lower border, none along the superior border. The graft is still plainly visible. Rating A-4, E-4, F-4.

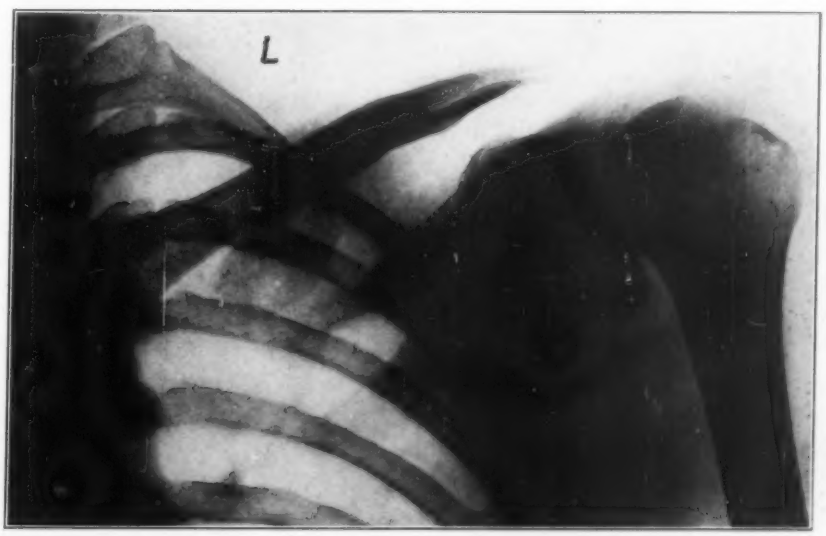


FIG. 10.

Case 6649. Eleven months postoperative.

FIG. 11

Case 6649. Eleven months postoperative.

Case No. 5811. Age fourteen years. Admitted June 14, 1928.

X-ray after attempt at closed reduction shows the same downward displacement of the distal fragment with about three-quarters of an inch overlapping, which is practically the same position as shown in the original x-ray on admission. X-rays August 8, 1929, fourteen months, and February 20, 1930, twenty months postoperative, show anatomical contour of the shoulder and clavicle. The bone peg is completely absorbed. Examination on the latter date shows a moderate scar, keloid in type, as is often seen with these colored patients. The shoulder operated upon is higher than the opposite shoulder, due to a fairly fixed left dorsolumbar curve which was present on first examination and had no relation to the fracture. Rating A-4, E-4, F-4.

Case No. 6649. Age eighteen years. Admitted March 19, 1929.

Boy states that between the time of fracture, March 5, 1929, and date of admission, two weeks later, there had been several attempts at closed reduction. Because of multiple pustules due to the adhesive strapping, open reduction was not performed until March 27, 1929, over three weeks after injury. X-ray on admission shows the usual deformity of the left clavicle with about one-half inch overriding. X-ray taken August 8, 1929, nineteen weeks postoperative, shows practically anatomical reposition with abundant callus. The bone peg is hardly discernible. X-ray February 21, 1930, eleven months postoperative, shows complete absorption of bone graft and a soft almost invisible scar, with normal contour of shoulder. Rating A-4, E-4, F-4.

SUMMARY

1. Closed reduction of clavicles is not as simple as one is led to believe from reading the literature; and even when the reduction is successful, maintaining of reduction often fails.

2. Even though it is not necessary to secure anatomical reduction to obtain good functional results, the resulting low short shoulder is not always a good result from the patient's point of view.

3. The resulting low shoulder following fractures of the clavicle must result in some degree of scoliosis of the spine.

4. Open reduction of the clavicle with introduction of intramedullary beef-bone graft is a simple operation and gives unusually efficient internal fixation so that the problem of external fixation appliances becomes unimportant.

A NEW SPRING BACK BRACE FOR FRACTURED CLAVICLES

BY H. W. SPIERS, M.D., LOS ANGELES, CALIFORNIA

Fractures of the clavicle present no new nor unusual problems, and almost one hundred per cent. unite. The extreme discomfort of some commonly used types of immobilization after reduction, and the frequent failure from a cosmetic standpoint, particularly in the female, makes any improvement welcome. The brace illustrated herein fulfills the indications, —outward, backward, and upward placement of the distal fragment,— allows freedom of use of the arms, and is ambulatory. It is simply a modification of the T-type back brace.

The two bars of the Taylor brace are fitted to the normal curves of the back and are fixed by a pelvic band. They are carried upward to well above the level of the acromion processes. The two cross bars are placed,— one at the top of the brace, extended out beyond the shoulders; the other, somewhat shorter than the upper, below the level of the axillae. The shoulder pad straps are fixed to the lower bar, carried through the axillae to be buckled to the upper bar. They pull the shoulder, and with it, the outer fragment backward and outward, acting as a sling, preventing downward displacement. The bars are of spring steel and if adjusted rightly, keep a constant pull, maintaining alignment and position.

FIG. 1

Rear view of brace. Note upper bar above acromion and lower bar below level of axillae.

FIG. 2

Front view of brace. Note chest strap attached to shoulder pads,— tightening or loosening this changes points of constant pressure and adds greatly to comfort.

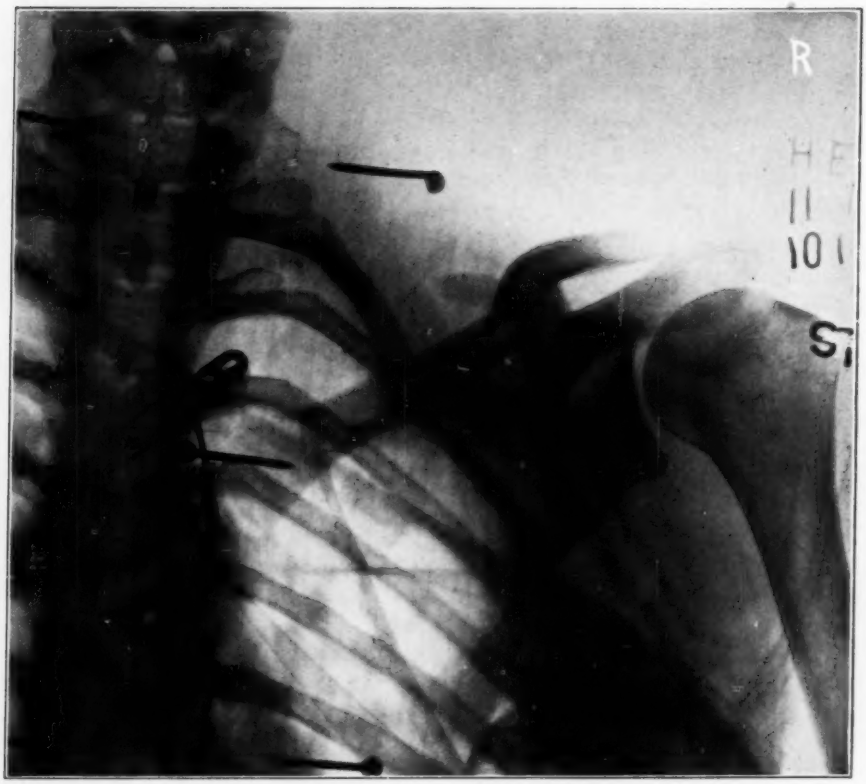


FIG. 3
Fracture of clavicle before reduction.

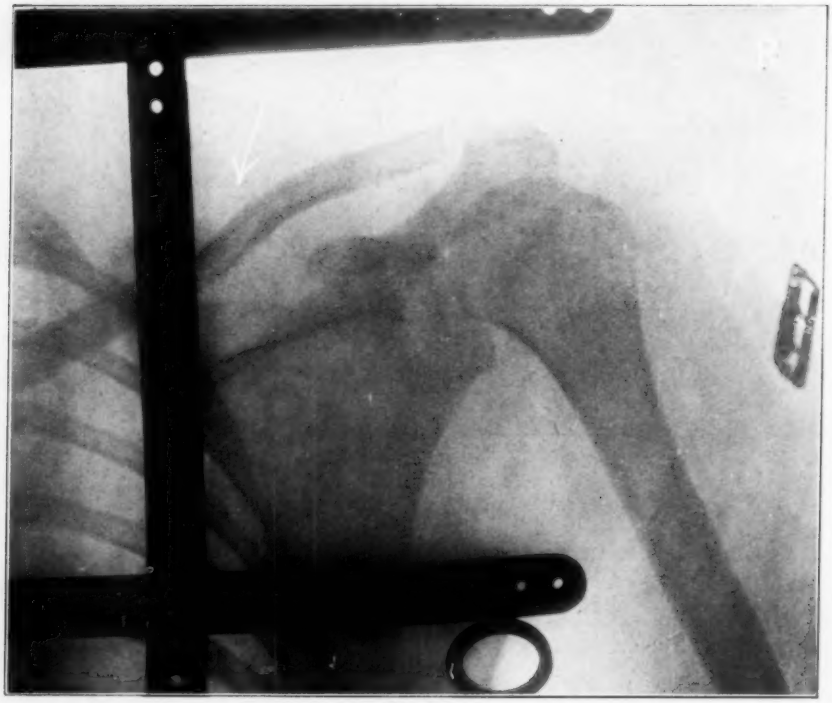


FIG. 4
Same case after application of spring back brace. End result was perfect, functionally and cosmetically.

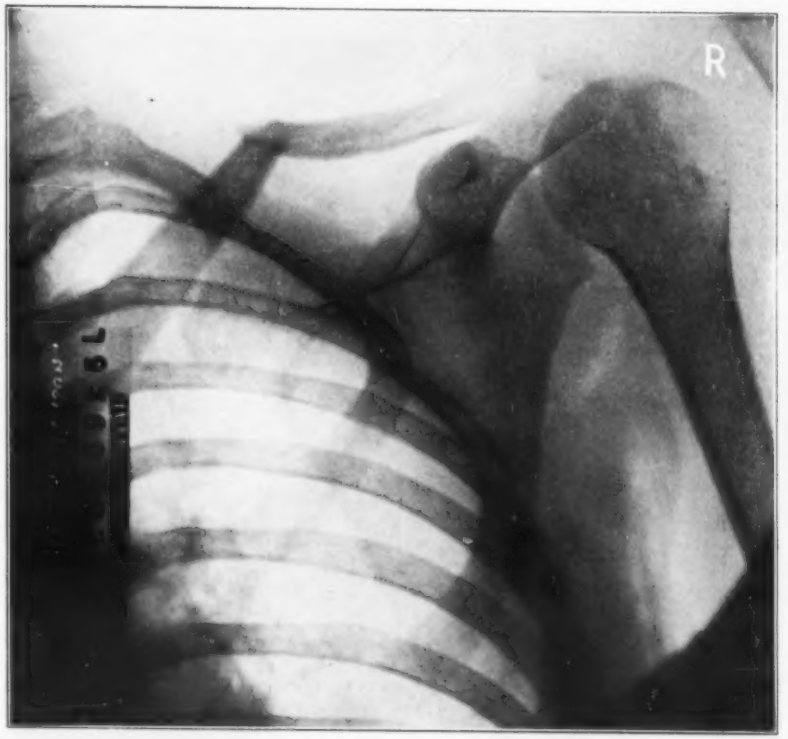


FIG. 5
Girl seen three and a half weeks after fracture occurred. Union quite firm.

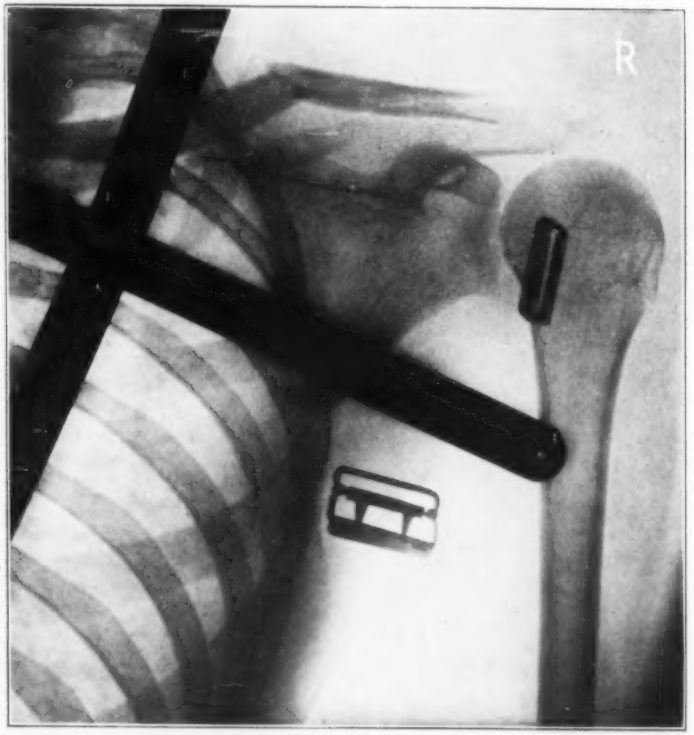


FIG. 6
Same case as Fig. 5 shortly after application of spring back brace. Cosmetic result excellent.

The point of constant pressure of the shoulder pad straps can be changed somewhat, thus adding to comfort, by the adjustment of a buckle strap across the chest, as illustrated. By keeping the lower cross bar below the level of the axillae, any circulatory obstruction that might be caused by the strap pads is effectually prevented.

Even in comminuted fractures of the clavicle this brace has given exceptionally good results.

AN INSTRUMENT TO FACILITATE THE PLACING OF PARHAM BANDS OR SUTURE MATERIAL AROUND BONE

BY C. F. EIKENBARY, M.D., F.A.C.S., SEATTLE, WASHINGTON

The instrument illustrated herewith is meant to facilitate the placing of Parham bands, suture material, wire, etc., around bone. The instrument consists of a handle about eight or ten inches long, and a curved portion (Fig. 1, *a*) of a size suitable for encircling a femur or tibia. The handle meets the curved portion at an angle of about forty-five degrees. If it were

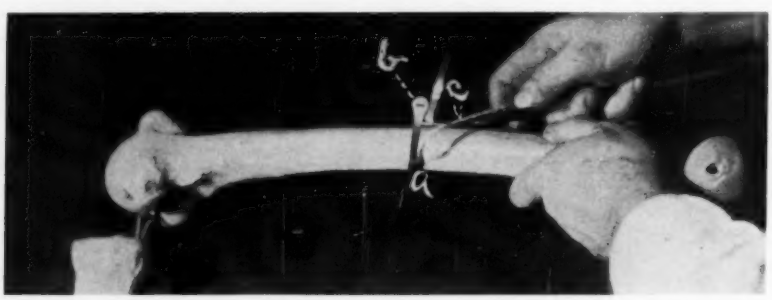


FIG. 1

Instrument encircling bone. Suture material (*c*) and Parham band (*b*) both shown in same picture to avoid extra illustration.

made so that the handle and curved portion met in a straight line, it would work equally well. The curved portion is tunneled so that after passing around a femur or tibia, for an oblique fracture for example, a Parham band (Fig. 1, *b*) can be passed through the tunnel, following which the instrument can be withdrawn, leaving the band in place. In the end of the curve a hole is drilled, so that suture material of any kind can be inserted and carried around the bone.

FIG. 2

Showing Parham band (*b*) after being passed through tunnel. Also suture material (*c*) threaded through eye of curved portion.

In Figure 1, the band (*b*) is shown passed through the curve. In Figure 1, *c* is a suture threaded through the eye ready to be carried around the bone. Figure 2 shows the suture (*c*) threaded through the eye at *x*, and also the Parham band (*b*). The band has been kinked at the points of entrance and exit of the tunnel in the curve.

PRESCRIPTION BLANK FOR THE MODIFICATION OF SHOES

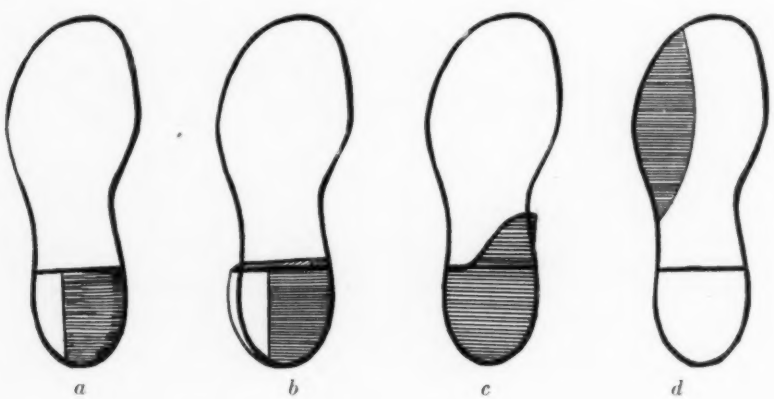
BY PHILIP LEWIN, M.D., CHICAGO, ILLINOIS

After reading Dr. Steindler's excellent article in *The Journal of Bone and Joint Surgery* for April, 1929 (XI, 272), it occurred to me that it would be worth while to reproduce a copy of the shoe-modification prescription blank designed by the writer while at the Base Hospital at Camp Grant, Illinois, about thirteen years ago.

FIG. 1

Prescription blank for modification of shoes.

This prescription blank simplifies directions to the shoe man, and saves much time for the orthopaedic surgeon. The blanks can be bound in books



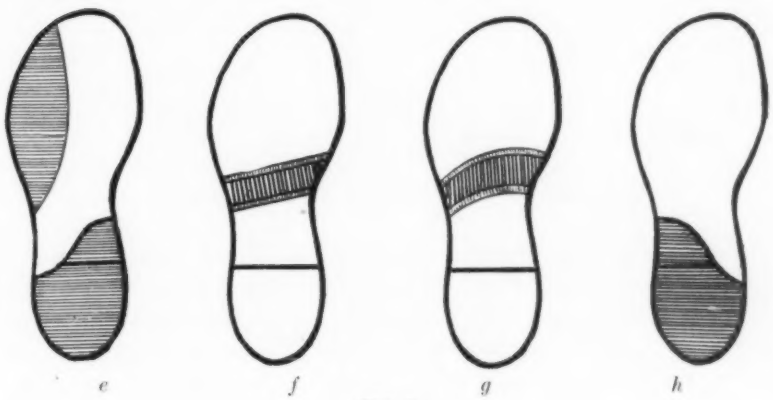


FIG. 2

Some of the modifications most commonly used:
a. Elevation of inner border of heel.
b. Elevation of inner border of a flared heel.
c. H. O. Thomas heel—prolongation forward and elevation of inner border.
d. Elevation of outer border of sole.
e. Combined Thomas heel plus elevation of outer border of sole.
f. Metatarsal cleat.
g. Metatarsal crescent.
h. Reversed Thomas heel. Outer border prolonged forward and elevated.

Note: The sketches in Figure 2 were made by Dr. D. H. Levinthal.

with two or three on a page like a check book. A yellow sheet underneath is desirable for the carbon copy which may be filed for a permanent record.

The modifications most commonly used are the special heel of Hugh Owen Thomas, modification of the sole, and the metatarsal crescent or cleat.

AN APPARATUS FOR TREATMENT OF FRACTURES OF THE OS CALCIS

BY EDWARD P. GILLETTE, A.B., M.D., TOLEDO, OHIO

In the impacted type of fracture of the os calcis, where a mass of bone is driven upward and outward to impinge against the external malleolus, subastragular arthrodesis may be indicated after a trial with the apparatus, which is to be described, has failed to approximate the fragments; but for the several other types of fracture of the os calcis this apparatus is simple and very satisfactory. It is well known in cases with loose fragments of bone, that by continued traction on the extremity the displaced fragment will fall into proper apposition and stay there more nearly than by any other method. Further, if joint surfaces are kept separated by traction in cases of fracture near the joint, less ultimate stiffness and pain of that joint ensues. It follows, also, that there is less irregularity of the joint surface should the fracture line run into the joint. Cotton and Henderson in 1916 suggested the insertion of a Steinmann pin in front of the Achilles tendon and above the bone, to make downward traction, while upward pressure was exerted by a felt pad under the arch.

With the above facts in mind, the following satisfactory traction apparatus was devised for treatment of fractures of the os calcis. With the knee in forty-five degrees flexion and the foot at right angles to the leg, a plaster cast is applied from mid-thigh to toes, the plaster being applied heavily just above the malleoli to make a strong base for the attachment of the traction apparatus. A square of felt covered with sheet wadding covers the hamstring tendons and another oblong piece covers the sole of the foot. Otherwise the cast is unpadded; the patient's heel is bared by cutting away the plaster, leaving the forefoot rigid in the cast. Then, after sterilizing the skin and injecting novocain, a rustless steel pin is inserted over the top of the os calcis in the angle between the joint and the Achilles tendon. Acriflavine or other dressings are applied about the skin punctures and the extension brackets as illustrated are applied to the cast

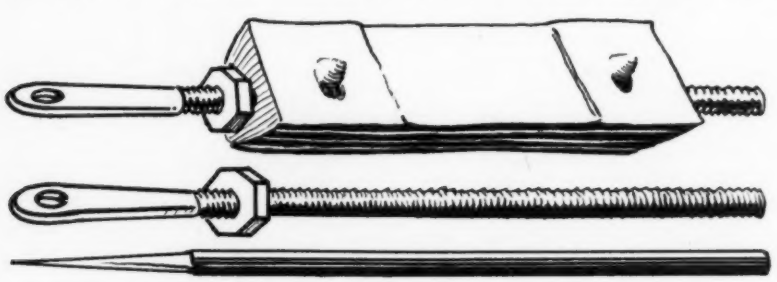


FIG. 1

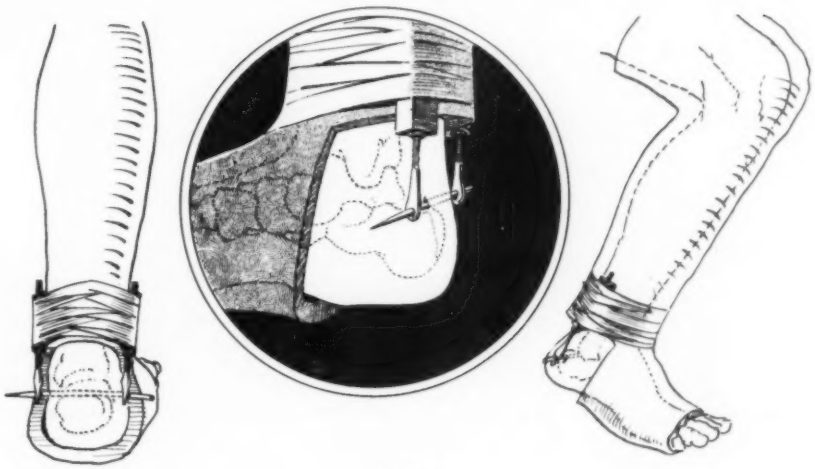


FIG. 2

and taped on, after which the traction is exerted by means of the turnbuckles on the brackets, and the fracture thus reduced accurately. The extension may be varied to suit needs on subsequent fluoroscopic check-up. One side may be lengthened more than the other to help correct lateral deviation. Some molding of a comminuted fracture may be necessary. The extension may be left on for four to six weeks. After removal of the pin, the puncture wounds heal readily with daily dressings, and weight-bearing may be started in eight to ten weeks. It is not necessary to cut the Achilles tendon.

The most serious objection to this apparatus is that the pin is introduced into traumatized tissue, and might lead to infection, but thus far the writer has had no trouble of this nature, although the apparatus has been applied on the day following fracture. This objection may be obviated if desired, however, by waiting ten days before placing the pin, to allow repair of the soft tissues and sufficient organization of the hematoma about the fracture to reduce the possibility of infection to a minimum; or the pin may be inserted through the Achilles tendon, thus keeping away from traumatized tissue.

A second objection is that the tremendous pressure exerted by the pin on the comparatively soft cancellous bone may cause a small area of pressure necrosis, but this fills in immediately on removal of the pin and causes no trouble of any kind.

Mr. H. G. Clash has helped in developing the mechanics of the apparatus and furnished the metal parts.

AN ADJUSTABLE BUCK'S EXTENSION

BY NATHAN H. RACHLIN, M.D., BROOKLYN, N. Y.

The writer was interested in the article by Dr. Hugh T. Jones, describing a new type of Buck's extension and published in June 1929 (Jones, H. T.: Simplified Apparatus for Buck's Extension. J. Am. Med. Assn., XCII, 1928, 1929). However, he felt that while the principle of the anchorage of the apparatus to the bed was good, the apparatus as described by Dr. Jones lacked adjustability, changes being limited to the horizontal positions. To obviate this difficulty, the apparatus presented herewith was devised by the author. It has been used with satisfaction at the Orthopaedic Department of the Neurologic Hospital, Welfare Island, New York, and at the Kings County Hospital, New York. The accompanying photographs demonstrate its uses.

Figure 1 shows apparatus attached to bed. *A:* Double collar around the cross bar of the bed, to prevent lateral swaying; *B:* Cross bar to slide pulley in any horizontal direction or, if to be used on the opposite side, to reverse the bar; *C:* The wheel with the screw adjustment is to set it in the required position; *D:* Vertical bar, with pulley at the top, can be raised or lowered to the required level by adjustment screw *E*.

FIG. 1

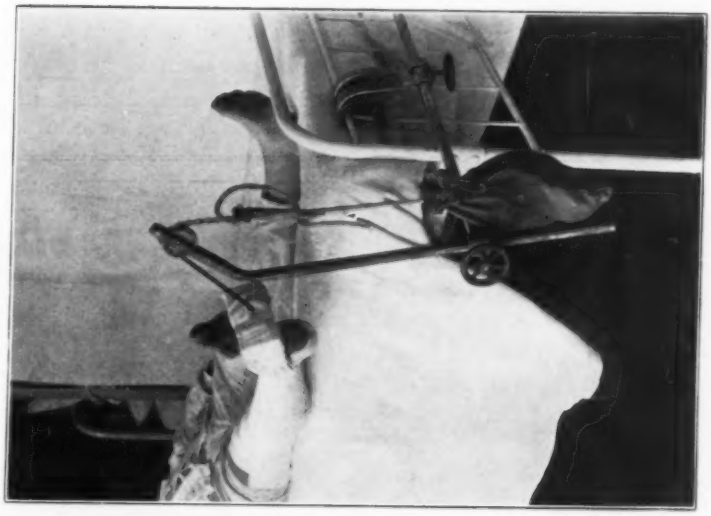


FIG. 4

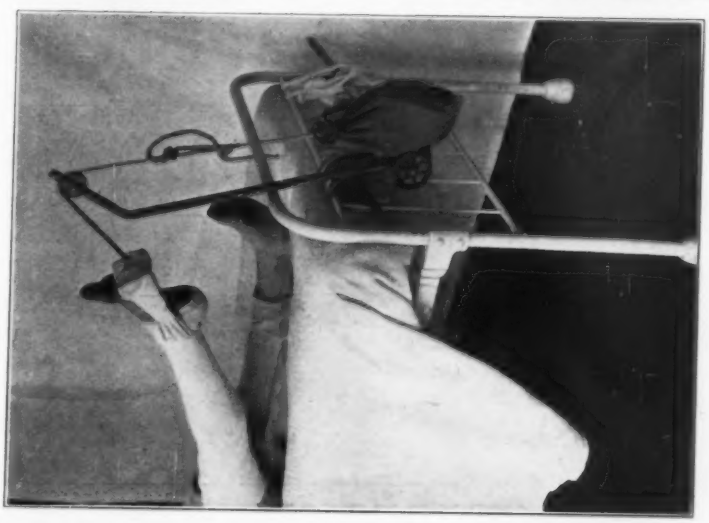


FIG. 3

FIG. 2

Figure 2 shows apparatus applied with traction to leg in a straight position with foot and leg slightly raised off the bed as in a case of fracture of the leg or lower part of thigh.

Figure 3 shows traction with thigh flexed, indicated in fractures of upper end of femur or for the purpose of correcting flexion deformities of the hip, the pulley being lowered as soon as the relaxed muscular spasm will permit.

Figure 4 shows traction in extreme abduction, the pulley being about two feet outside the bed level. This position is indicated in fractures of the neck of the femur and all acute injuries or infections in or about the hip joint.

Figure 5 shows apparatus in abduction and thigh flexion, indicating the degree of leverage pull that may be applied without disturbing its fixed point.

This instrument has the advantages of adaptability to all cases where traction is necessary, quick and easy application and equally simple change of position, cheapness, and durability—two of these supplying the average needs of a general hospital.

FIG. 5

AN IMPROVED SUSPENSION APPARATUS FOR THE APPLICATION OF BODY CASTS*

BY DANIEL H. LEVINTHAL, M.D., F.A.C.S., CHICAGO, ILLINOIS

The desirability of having a vertical suspension apparatus that would fold against the wall, when not in use, stimulated the author to devise the apparatus described herein. The usual apparatus consisting of four gas-pipe uprights secured to the floor and ceiling is impractical in a modern orthopaedic room, occupying valuable floor space and in the way while other orthopaedic procedures are being carried out.

By unscrewing the cross brace, *11*, from its attachment to the upper bar, *1*, the apparatus can be rolled against the wall on the four-inch rubber-tired casters, *10*.

The usual Sayre yoke and the leather halter are used unless the cast is to include the neck, occiput, and chin, in which case the split muslin sling described by Lewin is used[1].

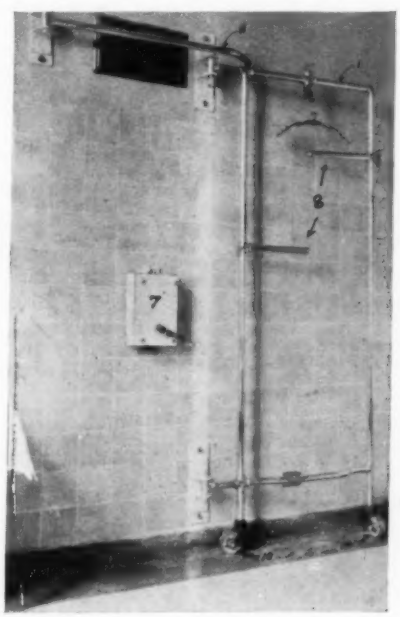


FIG. 1

Apparatus detached and rolled against the wall.

FIG. 2

Apparatus prepared for use.

*From the Orthopaedic Department of the Michael Reese Hospital.

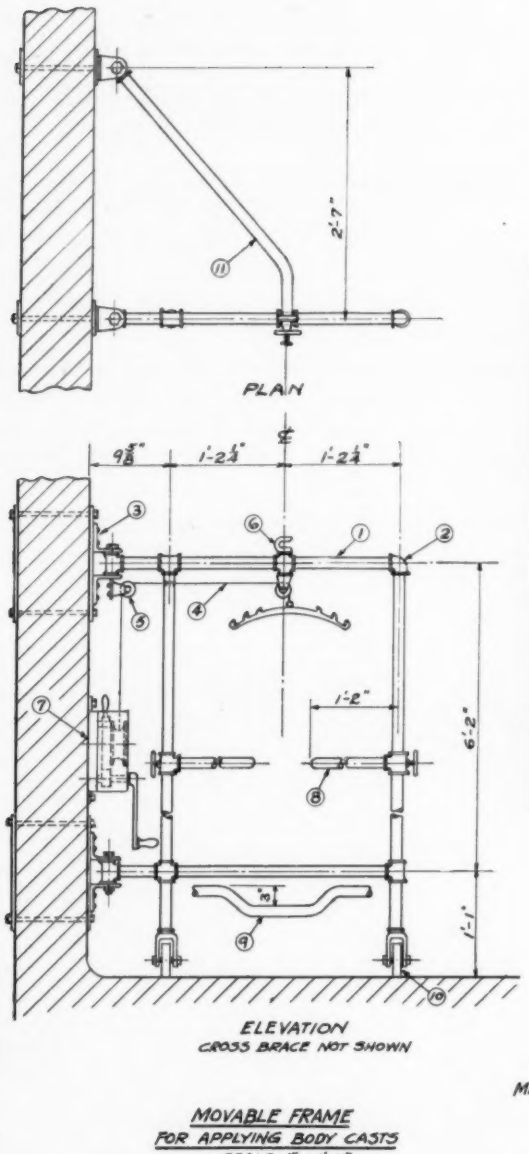

PLAN
2'-7"
9⅝"
1'-2¼"
1'-2¼"
1'-2"
6'-2"
1'-1"
ELEVATION
CROSS BRACE NOT SHOWN
— SPECIFICATIONS —
① BRASS PIPE, NICKEL PLATED 1" STD. IRON PIPE SIZE
② STD. I CAST BRASS FITTINGS - N.P.
③ BEARING ASSEMBLY - TWO 3½" x 3⅝" x ⅜ CB RIVETED TO 14" x 4" x ¼" 12-1" STD. BRASS T, BORED & BUSHED FOR RUNNING FIT WITH ½" DIA. PIN - COMPLETE ASSEMBLY FASTENED TO WALL AS SHOWN - FIN. IN BAKED GREY ENAMEL
④ ¼" STEEL CABLE
⑤ ⅞" O.D. BRASS PULLEY - N.P.
⑥ BRASS HOOK SCREWED INTO STD. 1" BRASS CROSS FOR SECURING CROSS BRACE
⑦ GEARED WINDLASS - OVERALL 12" x 8¼" x 3¼" - RATIO 3 TO 1 - C.I. CUT GEARS EQUIPPED WITH RATCHET - FIN. IN BAKED GREY ENAMEL - REMOVABLE HANDLE, N.P.
⑧ PATIENT'S HAND GRIP - "T" REAMED FOR SLIDING FIT ON PIPE - SET SCR. WITH 3" DIA. HAND WHEEL
⑨ LOWER CROSS BAR OFFSET TO PERMIT PATIENT TO STAND DIRECTLY IN LINE WITH POINT OF SUSPENSION
⑩ 4" RUBBER TIRED SWIVEL CASTER
⑪ CROSS BRACE - ½" BOLT FIXED IN ONE END - FASTENS SECURELY TO ⑥ BY MEANS OF CONE SHAPED WASHER & 3" DIA. HAND WHEEL WHEN NOT IN USE APPARATUS MAY BE WHEELED FLAT AGAINST WALL
MICHAEL REESE HOSPITAL
MAY 1, 1929
MOVABLE FRAME
FOR APPLYING BODY CASTS
SCALE 1" = 1'-0"

FIG. 3

Plan, elevation, and specifications.

The level of the shoulders as well as their anterior or posterior positions is adjusted by placing the hands on the hand grips, *8*, which can be placed and fixed in any position desired.

Suspension is made by means of a quarter-inch wire cable running over two brass pulleys to a geared windlass, *7*, which is equipped with a ratchet. The gears of the windlass have a three to one ratio.

Lateral pressure may be made by muslin bands fastened to the upright bars of the apparatus (Fig. 4). The lower bar of the frame has a three-inch offset which permits the patient to stand directly under the pulley.

The apparatus is made of nickel-plated brass tubing of one-inch standard iron pipe size. The entire frame is attached to the wall by means of three plates with through-and-through bolts.

FIG. 4

Application of body cast for scoliosis, showing suspension and lateral traction bands.

The author wishes to express his appreciation to Mr. W. Mezger, Assistant Superintendent, Michael Reese Hospital, for his co-operation in working out the plans and mechanical details of this apparatus.

1. LEWIN, P.: A Simple Removable Head Suspension Sling. J. Bone and Joint Surg., VIII, 422, 1926.

News Notes

The Forty-fourth Annual Meeting of the American Orthopaedic Association was held June 18 to 21. A Clinical Day in Boston on the eighteenth gave opportunity to visit the orthopaedic clinics of various hospitals. On the nineteenth the day was spent at the State Sanatorium at Lakeville. The other scientific sessions were held at Chatham on June 20 and 21. The guest of honor was Dr. Lorenz Böhler, of Vienna, who spoke on "The Treatment of Fractures". A more extended report of the meeting will appear in the next issue of *The Journal*.

Dr. DeForest P. Willard and Dr. James E. Wyant announce the removal of their offices to 1916 Spruce Street, Philadelphia, Pa.

Dr. Frank D. Dickson and Dr. Rex L. Diveley announce the removal of their offices to Suite 1600, Professional Building, Kansas City, Mo.

Dr. Burt G. Chollett of Toledo, Ohio, announces the association in his practice of Dr. Albert L. Bershon.

A questionnaire on the treatment of coxalgia has been issued by Dr. Marcel Galland, of Berck-Plage, France, and is prepared for the Congrès international de Thalassothérapie, to be held in Berck in 1931, and is probably in the hands of many of the readers. It is on a particularly important and interesting subject, on which a large amount of data is desired. It is hoped that those in possession of this circular will make a full return from their experience with this disease.

As successor to the late Prof. Pirquet in the Chair of Pediatrics at the **University of Vienna,** the faculty proposed *primo loco,* Prof. Pfaundler, Munich; *secundo loco,* Prof. Hamburger, Graz; *tertio loco,* Prof. Schick, New York. Later Prof. Pfaundler declined to accept the Chair.

Exercises in connection with the formal opening of the **International Factory Clinic,** at Leysin, Switzerland, were held on June 9. The establishment of this new clinic by Dr. Rollier is of special interest to those who have observed the development of occupational forms of therapy.

The Twenty-fifth Congress of the **Deutsche Orthopädischen Gesellschaft** will be held on September 15, 16, and 17, 1930, at Heidelberg. The preliminary program contains the following subjects: Development of the Infantile Deformities of the Leg; Pathology of the Arm; Tuberculosis of Bones and Joints, and Orthopaedics; The Principles of Mechanical Treatment in Orthopaedics.

To study the influence of Gerson's salt-free diet on tuberculosis, a committee of outstanding Viennese physicians, among them Prof. Eiselsberg, Prof. Durig, and Prof. Neumann, visited Sauerbruch's clinic at Berlin and Jesionek's clinic at Giessen. After thorough investigation and study of numerous patients during and after treatment, it was decided to found a private hospital in Vienna for the special purpose of trying the method on a larger material.

On November 16 and 17, 1929, the fourth meeting of the **Austrian Society for Public Health** took place in Vienna. "Physical Exercise" was the subject of discussion. Among the speakers were: Prof. Nieuwerhuis, Amsterdam, on "Sociology of Physical Exercise"; Docent Hofbauer, Vienna, on "Physiology and Pathology of Physical Exercise"; Prof. Rautmann, Germany, on "Disease and Physical Exercise"; Prof. Gaisböck, Innsbruck, on "Physician and Physical Exercise".

The next Congress of the **International Society of Orthopaedic Surgery** will be held in Paris on October 2, 3, and 4, 1930. As a part of the program there will be two symposia. The first will be on the subject "Treatment of Congenital Dislocation of the Hip after the Age of Fifteen Years", and reporters will be chosen from the United States, Germany, Great Britain, and Italy. The second symposium will be on "The Treatment of Wrist Injuries", and reporters will be selected from France, Holland, and Sweden. The American Committee is composed of Fred H. Albee, Chairman, William S. Baer, and Henry W. Meyerding.

Announcement is made of "A Post-graduate Week of Physical Therapy" in conjunction with the ninth annual scientific session of the **American Congress of Physical Therapy,** to be conducted September 8 to 12, 1930, at the New Hotel Jefferson, St. Louis, Mo. An intensive post-graduate week of physical therapy is promised. Elaborate plans have been perfected for teaching, demonstrations, and clinics. Full information may be obtained from the Executive Secretary, American Congress of Physical Therapy, Suite 716, 30 N. Michigan Ave., Chicago, Ill.

On January 1, 1930, the first institute and hospital for cancer research, the **Child Hospital,** was opened in Vienna. The founder of this institution is Mr. Child, of New York, and the medical director Dr. Edelmann, who is assisted by a number of distinguished specialists,—radiologist, gynecologist, surgeon, bacteriologist, and others.

To the **New York Post-Graduate Medical School and Hospital** has recently been presented the Oliver Rea Scholarship Fund, the gift of Mrs. Edith Oliver Rea. The fund is designed to promote advanced medical education and research in the United States, to stimulate and train teachers in medicine and surgery, and in other ways to increase efficiency in the practice of medicine and surgery. Scholarships are to be established to defray the expense in part or in full of the tuition of physicians at the New York Post-Graduate Medical School and Hospital, and a part of the income is to be used to provide salaries for scientific workers in medicine and surgery, or to establish prizes for valuable contributions to medical literature, or in any other manner to promote post-graduate medical education.

The British Orthopaedic Association held its spring meeting in Dublin on April 11 and 12. On Friday, April 11, the morning session was held at the Royal College of Physicians.

Sir William Wheeler read a paper on "Diaphysectomy", an operation he advocated under certain conditions, and he showed a young man, on whom twenty-one years previously he had excised the lower half of the femur for chronic osteomyelitis. The radiogram demonstrated perfect reformation of bone; there was three-quarters of an inch of shortening, and full range of movement at the knee joint. Sir William tentatively offered this operation as a method of treatment for gross malunited supracondylar fractures of the elbow in children. One such patient was shown, with full movement at the elbow and no deformity following this operation. He did not advocate the operation for adults.

In the discussion which followed:

Mr. Elmslie, the President, thought it required courage to perform diaphysectomy of the upper end of the femur for widespread tuberculous osteomyelitis.

Sir Robert Jones agreed with Mr. Elmslie. He took the opportunity of again emphasizing his practice in the treatment of supracondylar fracture of the humerus. Under anaesthesia he pulled on the straight arm, and then with his fingers hooked round the lower fragment flexed the elbow. After reduction he slung the wrist to the neck by means of a collar-and-cuff sling. He did not advocate splinting the elbow in full flexion, because that position, even in an uninjured arm, was liable to obliterate the radial pulse. After the lapse of seven days from the date of the accident he often failed to obtain full reduction, although the ultimate result of incomplete reduction was often very good.

Mr. Aitken approved of the block excision of the upper end of the femur as a means of insuring adequate drainage for chronic osteomyelitis.

Mr. McMurray said that he fought shy of the operation of diaphysectomy. He had seen three cases of non-union following the operation.

Mr. Platt drew attention to the unusual approach—an anterior longitudinal incision—used by Sir William in the malunited supracondylar fracture. He also commented on the absence of extraperiosteal new bone formation.

Sir William Wheeler, in reply, stated that after the operation on the boy with the malunited supracondylar fracture he had splinted the arm in a Thomas's splint in extension with traction for three weeks and then had placed the arm in a sling with the elbow flexed. He was glad to hear Sir Robert Jones emphasize the danger of splinting a fractured elbow in flexion before reducing displacement.

Mr. Harry Meade read a paper on "The Böhler Method of Treating Fractures", and showed numerous slides illustrating the excellent results which he had obtained by following these methods.

In the discussion which followed:

Mr. Bristow joined with Mr. Meade in his appreciation of the work of Böhler. He admired most in the clinic the thorough organization, the standardization of methods, and the exact attention to details.

Mr. Platt said that Dr. Böhler followed well established principles in advocating (1) rest to an injured joint, (2) flexion of the hip and knee in the treatment of a fractured leg, and (3) skeletal traction. In the treatment of fractured os calcis, his method was revolutionary and his results excellent. His wound treatment and the importance he placed on the healing of soft tissues,—*e.g.*, the sacrifice of bone to preserve skin—were worthy of note.

Mr. Elmslie wondered how much of Böhler's methods could usefully and safely be taught to the average student.

Mr. Meade, in reply, agreed that organization and team work were in great measure responsible for Böhler's excellent results. From personal experience he could recommend the use of local anaesthesia, as practised by Böhler, for the reduction of fractures.

Mr. W. Stevenson read a paper on "The Use of Radium in Orthopaedics". After a long experience he was convinced of the efficacy of radium emanations in softening scar tissue and in reducing pain.

Mr. Bankart expressed himself skeptical of the value of surface radiation for deep-seated inflammation.

Prof. W. S. Haughton spoke of the good effects he had observed after the treatment of scars by radium, as given by Mr. Stevenson. The scar might look the same, but the patient said that it felt looser and was less tender.

Mr. H. F. MacAuley read a paper on "Tuberculous Disease of the Neck of the Femur", contrasting the effect of non-operative with operative treatment, and advocated operating on tuberculous osteomyelitis in the neighborhood of a joint, with the object of creating an opening from the focus of infection to the exterior of the bone, along which

caseous material could obtain an exit. By establishing this extra-articular drainage one might prevent caseous material forcing its way into the joint cavity.

In the following sessions on April 11 and 12, there were operations performed and cases shown by Mr. W. Stevenson, Prof. W. S. Haughton, Sir William Wheeler, and Mr. H. F. MacAuley.

The following were elected Associate Members of the Association:
Dr. Marion A. Radcliffe-Taylor, Dunedin, New Zealand.
Thomas Smith Donovan, Oswestry.
H. E. Moore, Cheshire.
Matthew White, Glasgow.

PATHOLOGICAL CONFERENCE AT THE HOSPITAL FOR JOINT DISEASES, NEW YORK CITY

A Case of Neurogenic Sarcoma of the Forearm.

Dr. Samuel Kleinberg presented a tumor which microscopically proved to be a neurogenic sarcoma. The patient, a man twenty-six years old, came to the clinic because of a painful mass in the right forearm. He was well until nine years ago, when he noticed a small growth on the right forearm near the elbow. This increased in size slowly. Five years ago it became painful and was removed at the Mount Sinai Hospital, New York. The tumor recurred and became very sensitive to even light pressure. Consequently he was admitted to Dr. Kleinberg's Service for operation.

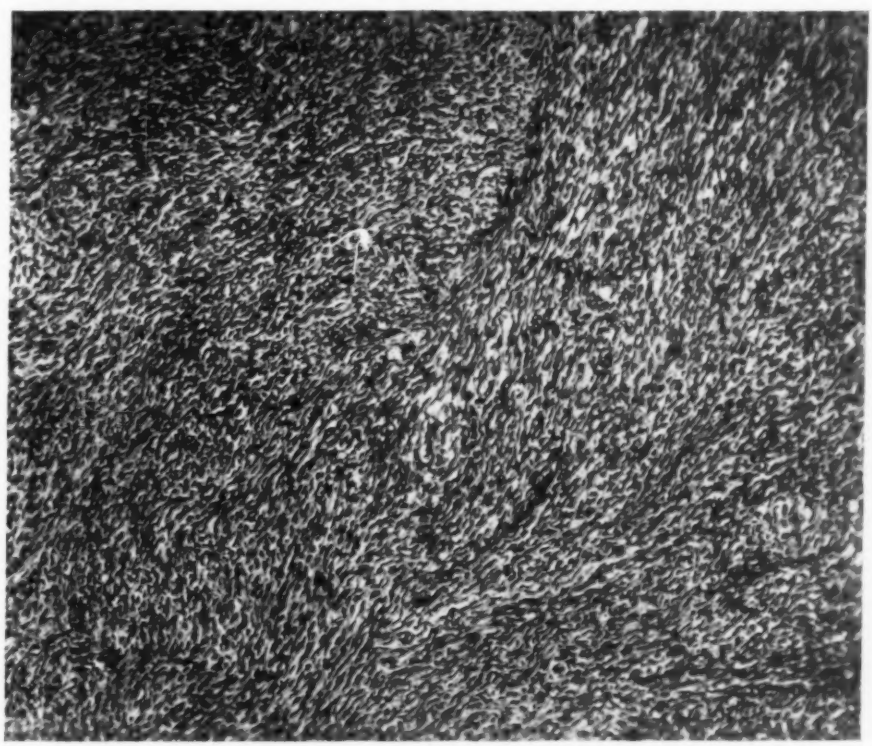


Fig. 1
Neurogenic sarcoma of forearm. × 100.

Examination showed a swelling on the inner aspect of the right forearm near the elbow. It was the size of a pigeon's egg, freely movable under the skin, attached to the deep tissues, elastic and extremely painful upon pressure. It was circumscribed. There was no atrophy of any of the muscles and no sensory disturbance in the forearm or hand. An x-ray picture of the elbow and a Wassermann test were negative. There were no similar tumors in any other part of the body. The tumor was thought to be a neuroma of a branch of the ulnar nerve and excision was advised.

The operation was performed on February 14, 1930. The tumor lay between the superficial and deep fascia. It was roughly oval, one and one-half by one inch in size. It penetrated the deep fascia and was adherent to the underlying muscle. It was not connected with the ulnar nerve nor with any recognizable nerve tissue. The tumor was removed completely, including a substantial thickness of muscle on its posterior aspect. The cut surface was gray and in places glistening. The mass was firm to the touch.

Dr. Henry L. Jaffe, Pathologist of the Hospital, reported as follows: The sections show a spindle-cell tumor with evidences of marked growth potency. The fineness of the spindle cells and their interlacing character indicate a neurogenic origin. There is apparent infiltration of the surrounding connective tissue by this tumor. (Fig. 1).

The tumor, from its very cellular consistency, is probably malignant,—at least so far as local recurrence is concerned. Consequently, although all of the neoplastic tissue was removed, the area of operation will be radiated in the hope of preventing any recurrence.

Osteogenic Sarcoma of Fourth Metacarpal Bone.

Dr. Leo Mayer reported a peculiar tumor of the fourth metacarpal bone of the left hand which microscopically was diagnosed as an osteogenic sarcoma. The patient, a girl of sixteen, gave a history of a swelling of three years' duration. Two and a half years ago, a partial removal of the tumor had been attempted; the tumor recurred promptly but did not grow rapidly until about six months ago. At the time of examination the tumor was the size of an orange and occupied the entire ulnar half of the left hand. Its consistency was elastic. X-ray picture (Fig. 2) showed a diffuse growth with complete destruction of the fourth metacarpal. Within the growth irregular trabeculae of bone could be seen. There were no metastases in the lungs, and no lymph node enlargement. Because of the absence of metastases and the sharp localization of the tumor, extirpation was decided upon.

Fig. 2

At operation a tumor mass measuring four inches long by two and one-half inches wide was found to be enveloped by a firm capsule. The mass was dissected out, together with the fourth and fifth metacarpal bones, without rupture of the capsule. A tibial bone graft was inserted to support the fourth and fifth fingers. The

specimen on section had a bony consistency. Little spicules of bone could be felt irregularly scattered through it. In spots there were cysts varying in size from pin-point to one-half inch in diameter. Dr. Jaffe, Pathologist of the Hospital, gave the following microscopic report:

Sections (Fig. 3) show a tumor with considerable intercellular matrix. The columns of intercellular matrix are lined by osteoblasts, most of which are spindle-shaped. A lot of the intercellular matrix and a considerable amount of the newly formed bone is abnormal bone and much of it is osteoid, but in some places trabeculae of rather normal appearing bone are seen. Between the trabeculae of the more normal bone there is cellular and vascular tissue. Osteoclasts are seen in some of the sections. A very peculiar picture is that of osteoid masses surrounded by osteoblasts, giving the appearance of rosettes.

Although the diagnosis of an osteogenic sarcoma has in this case been confirmed by Dr. Ewing, it would seem possible that the tumor is of a relative benignity. Thus far, three months after operation, there are no signs of any local recurrence or of any general metastases.

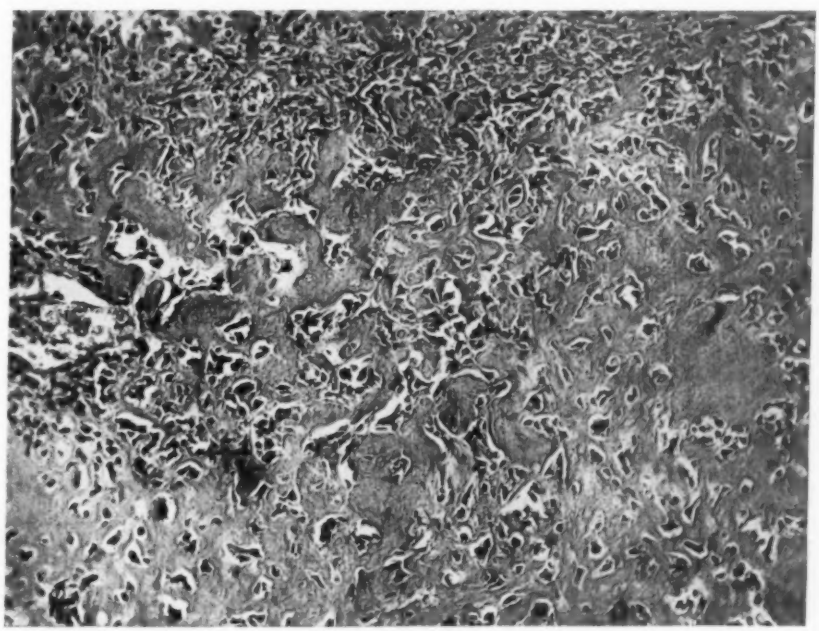


FIG. 3
× 100.

GIANT-CELL SARCOMA OF RIGHT TIBIA.

Dr. I. Reitzfeld reported a case of giant-cell sarcoma of the right tibia in a boy of seventeen, who was admitted to the Hospital on December 11, 1929, with the following history: About six months ago, he sustained a trivial injury to the right knee, causing mild disability. One month later, the knee became painful and swollen. The physical examination revealed a well nourished, white male, not acutely ill. His temperature, pulse, and respiration were normal. Over the upper region of the tibia there was bone enlargement present, and this was tender on pressure. There was some interference with motion at the knee.

X-ray picture showed a large area of necrosis in the tuberosities of the tibia, posteriorly projecting up into the involved epiphyses; this area measured about two

FIG. 4
× 125.

inches in diameter. Its outlines were sharply defined and showed no sclerosis or reactive changes. Irregular necrosis was present, but no typical trabeculations; no evidence of metastasis was discovered.

At operation, a large cavity was disclosed which was sharply defined and contained a bloody, grumous material. Sections of bony wall of the cavity and tissue from the cavity itself were sent to the laboratory for examination.

The report of the laboratory findings by Dr. Jaffe was as follows: Section (Fig. 4) showed a very cellular tumor. The cells are, for the most part, large spindle cells with vascular nuclei. Quite a number of mitotic figures are seen, and a large number of changes are seen in this tumor characterized by areas of degeneration and giant-cell formation. There are areas of hemorrhage in which organization of tissue and calcification and metaplastic new bone formation are present. The tumor is a type of benign process of bone with giant cells and spindle stroma. The boy was seen three months after operation with no signs of local recurrence or of any general metastasis.

CHRONIC TENOSYNOVITIS.

Dr. I. Zadek reported a case of chronic tenosynovitis—non-tuberculous—on the dorsum of the right wrist of a colored female, aged forty-two years. The swelling on the back of the right wrist had been present for about six months and increased gradually in size.

Examination prior to operation showed that the patient had a very marked swelling on the dorsal surface of the right wrist (Fig. 5). Swelling began at the radiocarpal joint and extended to the middle of the metacarpals, and occupied the entire width of the wrist. The swelling was elastic and seemed to fluctuate. There was sensitiveness to

pressure. The patient evidently had a chronic tenosynovitis. There was shortening of the extensors of the fingers, and she was unable to completely extend the metacarpophalangeal joints. X-ray examination did not show any lesion of the bone. Blood Wassermann was four plus.

The patient was operated upon January 17, 1930. The operation was performed under the tourniquet. A four-inch incision was made directly over the swelling. Adhesions were evident in the subcutaneous tissues. The inflammatory mass was extremely adherent down to the proximal row of carpal bones. When the inflammatory mass was opened, a few drops of synovial-like fluid exuded. There were no rice bodies in the mass, but there was one large body the size of a large almond, which was still firmly fixed in the mass. This was of the consistency of a rice body, but was not free. It was irregular in outline, conforming to the surrounding structures. All of the tendons involved in the inflammatory mass were very much attenuated, so that immediately distal to the area of inflammation, the tendons were at least twice the size that they were in the mass. Most of the inflammatory tissue was removed in one mass. All of the granulation tissue was not removed, some of it being adherent to the tendons which were badly frayed out. The extensor tendon of the index finger consisted of only a few small fibers, and the extensor of the little finger was ruptured during the process of dissection. The deeper granulation tissue was reddish in color whereas the more superficial part looked rather oedematous and soft.

FIG. 5
Chronic tenosynovitis.

The microscopic examination (Fig. 6) made by Dr. Henry L. Jaffe showed the following: Several sections show a tenosynovitis with villus formation. There is granulation-tissue formation with much vascularization underneath the lining synovial layer. There are no tubercles and no evidences of tuberculosis in the sections. The pathologic diagnosis is infectious tenosynovitis.

TUBERCULOUS SYNOVITIS OF KNEE.

Dr. H. D. Sonnenschein presented a case with history of pain and swelling of the left knee of one year's duration. The patient, L. R., male, fifty years old, gave no history of trauma or illness prior to the onset of this condition. Past history and family history irrelevant. Pain in knee had been gradually becoming worse. Patient walked with decided limp. Left knee was enlarged and there was a definite boggy feel to the part. No fluid was obtained on aspiration. Angle of greatest extension was 170 degrees. Angle of greatest flexion, ninety degrees. Beyond ninety degrees flexion there was considerable pain. Tenderness was elicited on pressure over each side of the patella. No local heat was present. Radiographic examination was negative, also general physical examination. The quantitative tuberculin test was slightly positive. Impression was that patient was suffering with a chronic villous arthritis of the left knee. Synovectomy was advised.

Patient was operated on October 28, 1929. At operation the synovia was found to be markedly thickened, of a reddish-purplish hue, and covered with an enormous

FIG. 6

Infectious tenosynovitis. × 50.

number of organized flakes of fibrin. These flakes measured about one inch long and three-eighths of an inch wide and had the consistency of paraffin. A great number of these flakes were present in the joint cavity. The synovia was removed, freeing itself very easily. The articular cartilages and bones were normal.

Pathologic report by Dr. Henry L. Jaffe:

In the synovial membrane and the perisynovia there are numerous conglomerate tubercles. In places the synovia is indurated with pigmented material giving it an xanthomatous appearance. Diagnosis: Tuberculous synovitis of knee (Fig. 7).

METASTATIC CARCINOMA OF ILIUM.

Dr. Henry Milch presented the case of R. C., age fifty-two, who was admitted to the hospital with a diagnosis of tuberculosis of the right wrist and left hip. One year before, the patient had had a lump on the right hand removed, since which time the wound had continuously discharged pus. For the past ten months, the patient has complained of pain in the left hip joint for which he had been treated in various hospitals with casts and other apparatus. There was definite limitation of motion in the left hip in all directions, with a fixed flexion deformity. The x-ray of the bones of the body showed destruction of the ilium on both sides, more marked on the left, destruction of the twelfth rib on the right side, and of the sixth and seventh ribs on the left side. The skull and the right wrist showed evidence of destruction. A diagnosis of metastatic malignancy was made, and biopsy was suggested.

At operation, the whole of the left ilium was found spongy, and a part of the anterior superior spine was removed for examination. Laboratory report (Fig. 8) showed grossly, some pieces of yellow-white tumor tissue. Microscopic section showed that "We are dealing with a malignant tumor in the bone, which, if I had nothing else to go by, I would attempt to call a liposarcoma, because of the peculiar general cytologic picture that resembles no common primary sarcoma in bone, and does not appear like a metastatic carcinoma. However this patient died, an autopsy was performed, and, since it showed carcinoma in the kidney with metastases, this bone lesion is undoubtedly a metastatic carcinoma from the kidney."

It has been the experience of other physicians that about twenty-five per cent. of tumor cases in bone are erroneously diagnosed, even by a combination of competent clinicians and roentgenologists. The interest in the case here presented lies in the fact

FIG. 7
Tuberculous synovitis of knee. × 75.

that though a gross diagnosis was made on x-ray findings, a definite pathologic diagnosis could not be made, even on microscopic section. Had it not been for the autopsy findings, this case might have been considered as similar to the case of liposarcoma previously presented at this meeting.

CHRONIC POLYPOID SYNOVITIS (NON-TUBERCULOUS).

Dr. H. C. Stein reported a case of bilateral chronic hydrarthrosis of the knee due to polypoid synovitis cured by synovectomy.

The patient was a Swedish male, single, age thirty-five, laborer. He applied at the Out Patient Department of the Hospital for Joint Diseases on June 1927, complaining of instability, weakness, and swelling of both knee joints, so pronounced that he was forced to give up his occupation. The onset was insidious, about sixteen years ago on the left side and ten years ago on the right. There was no traumatic or venereal history.

Physical examination revealed marked effusion, very much distended synovia, and laxity of both knee joints. There was no pain, limitation of motion, nor spasm. Bacteriologic serologic, and radiographic examinations were essentially negative. He had been treated at a number of the leading institutions by various methods,—such as compression bandages, immobilization of the left knee in plaster for three years, repeated aspirations, vaccines, physiotherapy, antiluetic treatment, etc.; but his condition became progressively worse.

On July 2, 1927, an open operation was performed on the left knee, an internal parapatellar approach being used. The synovial cavity was very much distended and contained about eight ounces of amber-colored fluid. The synovia was very much thickened, and from various points within the suprapatellar pouch sprang numerous

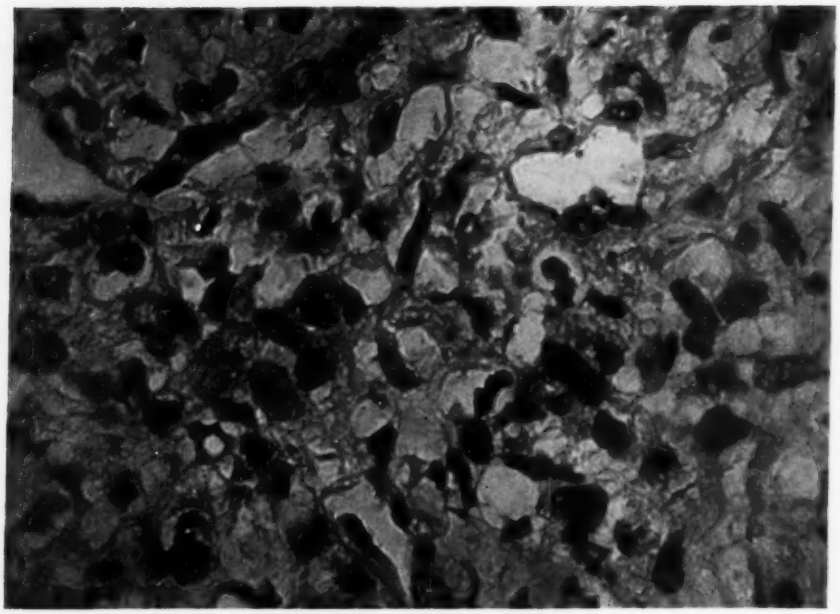


FIG. 8

Metastatic carcinoma of kidney in bone. × 565.

pedunculated polypoid masses, resembling bunches of small grapes, each mass consisting of about fifteen or twenty small polypoid bodies, ranging in size from one-quarter to three-eighths of an inch in diameter (Fig. 9). A complete synovectomy was performed, including the removal of the fat pads and menisci.

Complete functional cure resulted from operation. Patient was able to resume work. There was no recurrence of fluid, and stability became normal.

About four weeks ago, the right knee was operated upon. Findings were similar but not quite so marked. Partial synovectomy was performed. Patient is now able to walk about without pain; he has good stability and almost a normal range of motion.

The pathologist's report on the synovial membrane was as follows (S-2152):

Gross: Specimen consisted of practically all of the synovial membrane with some of the surrounding fatty tissue. Everywhere the synovial membrane is extremely thickened. In places the synovial layer is hypertrophied and the appearance is somewhat like a bladder mucous membrane. In other places the synovial membrane is thinned out and the underlying tissues have undergone a fibrous hyaline change and the synovial layer and underlying tissues appear more like attenuated tendon. In some places there are rugae transversing the joint surface of the synovial membrane and in other places there are large villus formations.

FIG. 9

Microscopic: Sections show a chronic synovitis with hypertrophy of the lining endometrium, granulation tissue underneath the endometrium, growing up of the endometrium in polypoid-like form. Hyaline fibrous tissue replacement of the

endometrium with endometrial tissue in other places.

Diagnosis: Chronic polypoid synovitis—non-tuberculous.

GANGLION OF THE WRIST.

Dr. J. Kreitman presented the case of M. W. aged twelve. He was admitted to the service of Dr. Samuel Kleinberg on February 28, 1930 with a diagnosis of ganglion on the dorsum of the left wrist. He had had a firm non-tender cystic mass on his left wrist for

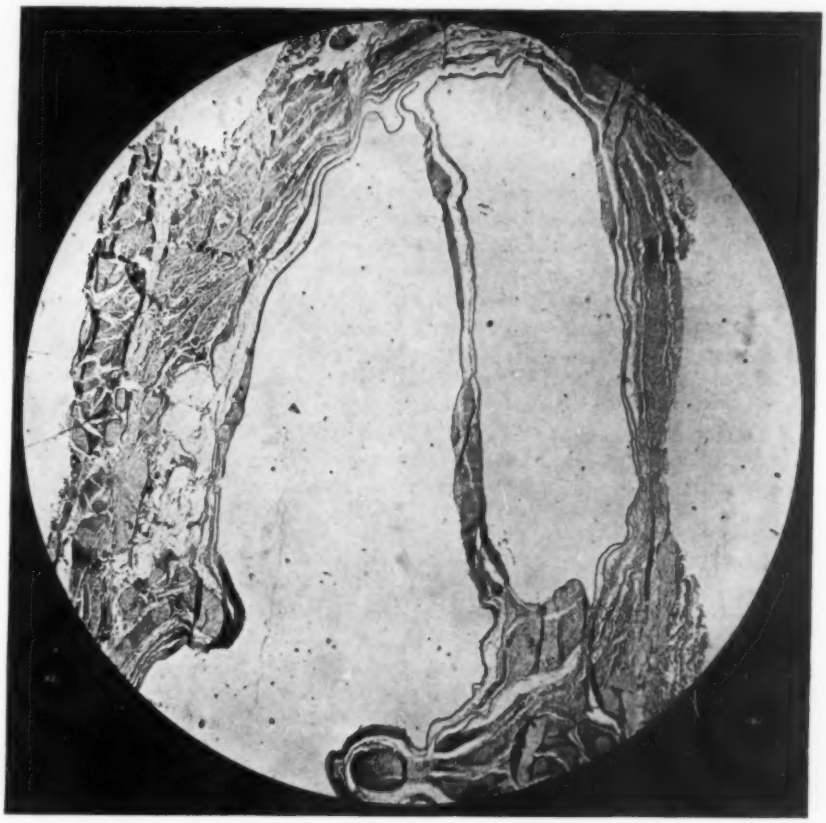


FIG. 10
Ganglion. × 20.

a period of eight months. During this entire period, the mass had never been painful and had not changed in size or character.

Examination of the local condition revealed a soft cystic mass, one by one and a half-inches in size, on dorsum of the left wrist. It was not adherent to skin or to deep structures. It was not tender on palpation. Flexion of the wrist made this mass more prominent.

On February 28, 1930, under local infiltration anaesthesia, this cystic mass was excised. It was found to lead into the wrist joint. On gross examination, specimen was found to be a multilocular, sacular structure, the walls of which were lined by a thin, white membrane. Microscopic examination showed a typical fibrous sac lined by flattened connective-tissue cells (Fig. 10).

ON THE CARE OF CRIPPLES IN SWEDEN

BY HARALD NILSONNE, M.D., STOCKHOLM, SWEDEN

By request.

In relation to its population Sweden is a small country with relatively small financial resources. However, the treatment of cripples in Sweden occupies a very high position, and was early recognized as a public concern. State-aided organizations have sprung up, furnishing to the individual effectual help: orthopaedic treatment, instruction in different handicrafts, and the placing of the invalids in suitable occupations. The aim is to assist the invalid capable of work to become socially useful and self-supporting. The public contribution to the aid of the invalids is thus not so much colored by philanthrophy as by national economy and general hygiene.

It may rightly be said that the modern care of cripples began in Scandinavia. Hans Knudsen, a Danish clergyman, is reckoned as the father of the modern form of this social welfare. He based his activities on the principle—then new, but now so self-evident—that the invalid should first have effective specialized medical treatment for his crippling condition, and then should be put in training in some handicraft adapted to his invalidism. In 1872 Knudsen founded in Copenhagen an orthopaedic out-patient department to which later was added a small clinic besides trade schools.

In Sweden orthopaedic hospitals were inaugurated in Gothenburg in 1885, in Hälsingborg in 1887, and in Stockholm in 1892. At first these institutions were ordinary trade schools of the old type. To the hospital in Gothenburg a small orthopaedic out-patient department was added in 1890, but the rational elaboration of Knudsen's idea did not take place until later.

It so happened that in Sweden occurred in 1911–1912 a terrible epidemic of poliomyelitis. In the course of two years there were 14,000 cases in a population of 5,000,000. This caused the authorities to adopt special measures and the three above institutions were then charged with the task of caring for the cripples. In 1913 these institutions were reorganized into their present modern type: a general orthopaedic out-patient department, an orthopaedic clinic, brace workshop, and trade schools and, as an annex, a boarding school for invalid children of school age.

Each cripple institution[1] is owned and cared for by an independent association and thus entirely separated from State and community health organizations. The running expenses, on the other hand, are divided between the State and those county councils whose patients are treated in the institutions. The State Board of Health supervises the three institutions through a health inspector and is kept informed by an accountant on the Board of Directors as to how the State contributions are used.

An important factor in the development of these cripple institutions and the central position they have come to occupy in the treatment of invalids has been the Old Age and Disablement Insurance Act enacted in 1914. For soon it was found that invalid insurance without preventive treatment did not truly interpret the essence of the bill. This caused the State organization for invalid pensioning, the Royal Board of Pensions, to get in touch with the cripple institutions in order to utilize the experiences gained there as regards invalids and their treatment. The Royal Board of Pensions, run on ordinary insurance economic principles, found it sound business to reduce the invalidism in those applying for pensions on such ground and, if possible, again render them self-supporting by training them in some suitable trade.

The three orthopaedic hospitals carry on their work regionally,—*i.e.*, each of them drawing their patients from its own district. All applicants, whether in need of orthopaedic treatment, artificial limbs and braces, or training in some trade, first have to pass through the Out-patient Department which is to be regarded as the center of the organization. The patients are generally sent to the institutions by provincial doctors or other medical men paid by the State, either directly or by the agency of the Royal

Board of Pensions. In cases where such provision is necessary, the traveling expenses are paid by the State; should the patient also be unable to travel by himself an attendant is provided. The importance of this will be realized when the fact is considered that Sweden is a country measuring 975 miles from south to north with a sparse population amounting to about six millions.

The patient is admitted to the Out-patient Department where the treatment is planned, preceding admission to the clinic, and often with the view of cooperation with those sanatoria where the Royal Board of Pensions has its own therapeutic activities.[2] Out-patients are supplied with the necessary braces and artificial limbs from the hospital workshops. All brace appliances are thus ordered by orthopaedic experts. The extent of this form of activity is considerable: more than 200 artificial limbs for amputated lower extremities alone were made at the orthopaedic hospital in Stockholm during 1929. The question as to trade instruction if required is also decided at the Out-patient Department by the doctor in conjunction with the matron who is specially qualified to advise on these matters.

The training expenses in each individual case are paid by the Royal Board of Pensions, the State, and the community from which the patient comes. This training is organized in boarding schools attached to the orthopaedic hospitals. Only pupils with less serious invalidism are trained by the Royal Board of Pensions, such training being arranged for near the patient's home and given by some skilled craftsman. The training in skilled trades is mainly concentrated on handicrafts,—such as shoemaking, tailoring, painting, carpentering, bookbinding, sewing, machine knitting, etc. In recent years, however, an effort has been made to find new fields. Thus some of the greater industries have been approached in the matter and have been willing to admit invalids for training as motor-car repairers, skilled fitters, electricians, instrument fitters, etc.

The orthopaedic institutions have a common organization and are represented by a committee (the S.V.C.K.), which is thus a sort of private ministry for the three institutions to which questions of common interest are referred.

It may be asked what is the outcome, socially and financially, of this special training of the invalids in various trades. The labor market in Sweden is not one of the best and in view of the on-rushing industrialization, handicraft has in many places rather troublesome times. With the view of obtaining information on this question, the social curator at each orthopaedic hospital began four years ago to pay annual visits to recent pupils in the various trades. Every pupil is reported on, particulars being noted on special cards as to his or her capacity for work, possibility of obtaining work, social surroundings, earnings, and pension or poor law relief, if any. The first part of this material has been statistically prepared by the writer in conjunction with Mr. K. Alderin, registrar to the Royal Board of Pensions.[3]

With regard to the results of the training, the material has been divided into three groups.

Group A: Cases where full maintenance is attained in the trade learned at the hospital.

Group B: Cases of partial maintenance,—*i.e.*, those who work in their trade, but in addition obtain a small amount of relief from the Pension Board, and also those who are considered capable of maintaining themselves by their trade without any form of relief because of the fact that they live in their homes free of cost or only have to pay for board and lodging at a very low rate.

Group C: Comprising those for whom the training did not bring any ability to work or to maintain themselves by their trade.

The results may be classified as follows:

Group A: eighty-one cases; *Group B:* eighty-two cases; *Group C:* thirty-three cases.

It will thus be found that no less than forty-one per cent. have attained full maintenance capacity, forty-two per cent. partial maintenance capacity, while only seventeen per cent. failed to attain either working or maintenance capacity. Considering that we are generally dealing here with a high degree of crippling, it must be admitted

that the result is surprisingly good. It may further be mentioned that of the thirty-three cases in Group C, nine were incapable of work on account of progressive disease after the training (pulmonary tuberculosis, etc.); if these cases are deducted, a figure of only twelve per cent is obtained for Group C. These examinations of recent pupils at the hospital training schools are still in progress and are intended to include all such pupils. When completed, it is expected that these end results will yield extremely valuable information about the relation of the invalid to society, his chances of learning a trade, and his social usefulness,—all questions of vital interest for every community from the point of view of ethics as well as social hygiene.

Finally, it may be mentioned that the treatment of cripples has obtained a firm footing in modern medical training. In 1912 a professorship in Orthopaedics was established at the Royal Caroline Institute in Stockholm. The holder of this appointment is also Senior Surgeon at the Stockholm Orthopaedic Hospital, the clinic of which thus serves as the university training clinic in orthopaedics of the Royal Caroline Institute. There is still another clinical appointment at the Lund University in conjunction with the Orthopaedic Hospital Clinic. Since 1928 medical students have had to undergo a compulsory course of training in orthopaedics for six weeks, the course running simultaneously with their clinical training in surgery.

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At the meeting of the **Reunion d'Orthopédie et de Chirurgie de l'Appareil Moteur de Bordeaux,** held on February 20, 1930, a paper was presented by Dr. Charles Lasserre on "Solitary Cyst of the Tibia". He said that since the presentation of Lecene and Lenormant, in 1912, the first French study of this question, and the report of Roederer at the Congress in 1923, there have been increasing publications on the subject; the clinical and x-ray characteristics have been elaborated, but the etiology and the pathology still remain obscure. As to the best method of treatment, opinions also differ. Some surgeons (Lenormant: Bull. et Mém. de la Soc. nat. de Chir., LIV, 96, 1928) believe that many of these cysts have a tendency to disappear with the progress of the ossification, and advise in some cases the simple opening, either with or without curettage. On the other hand, after having seen many cases of osseous cysts, operated on without graft by simple opening, develop spontaneous fracture, Mouchet believes that the osteoperiosteal graft, applied with crushing of the incised osseous cyst, furnishes more opportunity for complete cure, and is more certain in its end results.

Dr. Lasserre reports a case following a blow on the right leg in March 1929. In June 1929, locomotion was difficult and there was an increase in size of the lower portion of the right tibia, with the skin normal in appearance; the bone was somewhat swollen; palpation was painful. The x-ray, anteroposterior view, showed the classic appearance of the essential bone cyst. The lateral view showed the cavity, five and one-half centimeters long and three centimeters wide, with the anterior bounderies of the cavity corresponding to the cortex of the tibia, which was extremely thin but continuous and regular. The tibia on the posterior aspect showed a supporting buttress seven millimeters in thickness, particularly thin and fragile.

Operation on June 6, 1929, by a long incision on the antero-internal aspect of the tibia; the cyst was opened; the anterior wall, which was extremely thin, was cut through with curved scissors as far as the contact with the resisting bone of the area. The con-

FIG. 1
X-ray June 3, 1929.

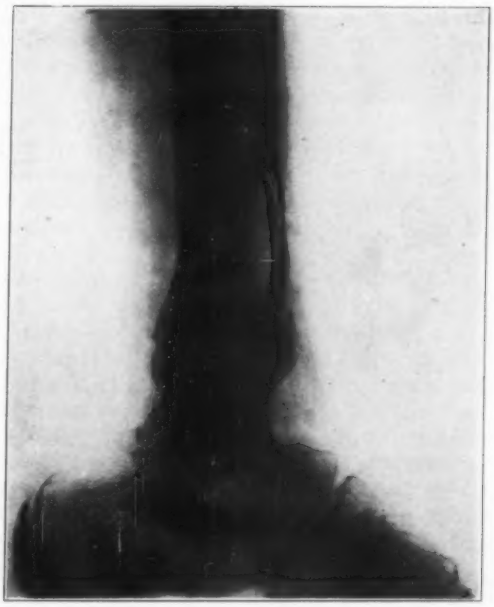

FIG. 2
X-ray August 20, 1929.

tents were a lemon-colored fluid, with considerable membraneous debris. The cavity was carefully curetted, to insure a notch in the border of the live bone, above and below, into which to insert the osteo-periosteal graft. A flexible osteo-periosteal graft as long as possible was raised from the tibia rolled upon itself with the periosteum on the inside; this was then placed into the cavity and pressed into place. The two extremities of the graft were then inserted in these two ridges of bone prepared at the level of the tibia. The cavity was then crushed in, with the expectation that the anterior portion of the tibia would finally be reconstructed. Wound was closed without drainage, followed by immobilization in a fenestrated plaster. The postoperative condition was normal; patient walked with the plaster at the end of one and one-half months, and the plaster was removed at the end of two months.

FIG. 3
X-ray December 21, 1929.

The histologic examination, by Dr. Bonnard, revealed a solid tumor, resembling connective tissue, yellow, and fibroblastic in character. In the center of the cellular mass were certain osseous areas, one of which

was in the process of formation,—others were in the process of regression. The circulation was well developed, and in certain areas there was the formation of lacunae, with the walls somewhat elevated and apparently vascular under pressure. The hemorrhages had provoked isolated cystic reactions at certain points which were very active, and which in two areas were characterized by numerous plasmodial masses with many foci, oval, scattered without any order, in an abundant cytoplasm, clearly limited and neutrophile. There were no signs of malignant transformation. The direct examination by culture did not show any growth of micro-organisms. From these observations, one can conclude that it is a question of a para-inflammatory phenomenon, as shown by the fibromatosis with myeloplaxes, following the hemorrhages.

The x-ray on August 20, 1929 (Fig. 2), showed the walls of the cavity to be in contact with the periosteal graft. The graft showed signs of beginning proliferation, spreading out on the anterior portion of the cortex of the bone. The radiograph on December 21, 1929 (Fig. 3), showed a marked proliferation concentric to the graft. Above, the appearance is that of a bony cortex of a normal density and thickness at the level of which it is no longer possible to define the strata of the graft. Behind, to a slight extent, a distance of one to two millimeters separated the proliferating graft from the dense walls of the cyst. The two extremities were closely united with the neighboring bone. The extreme thinness of the bone produces a definite risk of a fracture which should not be disregarded, and therefore the necessity of great care to avoid this complication by the crushing in of the cavity with the periosteal graft.

It is not necessary to completely fill the cavity, for the osteoperiosteal grafts form an active center for bone regeneration, but it is necessary that they be carefully placed. It is for this purpose and to direct the ossification that we have adopted this particular placing of the periosteal transplant, rolled and placed into the bone at its two extremities.

FIG. 4

At the meeting of the same Society on March 20, 1930, numerous interesting papers were presented.

Dr. Lasserre presented "A Rare Traumatic Lesion of the Anterior Tarsus". This unusual observation of a transverse fracture of the second and third cuneiforms followed

a fall on the anterior portion of the right foot in slight torsion. A difficulty in diagnosis sometimes encountered is the notch seen in the first cuneiform, showing at the anterior middle third about seven millimeters in length, with irregular contour. The author also draws attention to the frequent existence of the supernumerary bones of the tarsus, which gives a picture very closely resembling a fracture without displacement.

A study of the anterior process of the first cuneiform, with its variations and its rôle in the morphology of the foot, was presented by Dr. Lasserre. This paper showed a careful study of this peculiar deformity of the dorsal surface of the foot, with an anatomic description of the exact site of this process and its relations to the neighboring tendons. This prominence corresponds to the junction of the dorsal portion with the forefoot, and from the pathologic point of view this process seems exposed to frequent trauma from contact, and may become painful. In certain cases, as with adolescents during rapid growth, Dr. Lasserre called attention to the existence of this prominent pinnacle process, and a similar inflammatory area on the anterior part of the tibia. The x-ray shows clearly the process extending over a large area on the superior portion of the bipartite cuneiform (Fig. 4). This peculiarity tends to the development in certain adolescents of a true apophysitis, with the abnormal development of the first cuneiform, attended by rather painful symptoms (Fig. 5). The treatment is purely prophylactic.

FIG. 5

FIG. 6

Dr. Lasserre described a case of congenital varus metatarsus in the cuneiform metatarsal area, and showed radiographs (Fig. 6) of a man forty-five years old with a congenital metatarsal varus, without valgus, of the posterior tarsus, which he considers a rare affection. It is evidently a form of congenital club-foot,—an exceptional variety—and a deformity which presents many degrees. The essential area of greatest deformity is in the metatarsal cuneiform articulation and is an adduction at this joint, with deformity and malposition to the first cuneiform, associated with such other conditions as the incurving of the metatarsal diaphyses, valgus of the anterior tarsus, subluxation of the subastragalar area, and valgus of the posterior tarsus (Fig. 7).

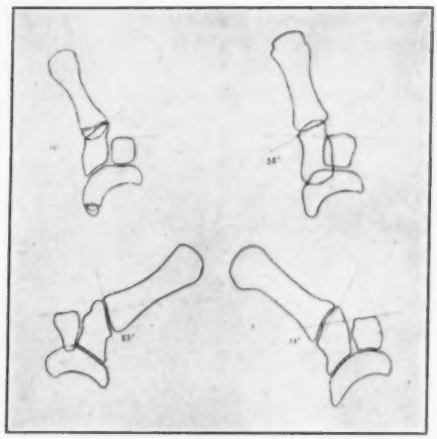

FIG. 7

Diagram showing normal metatarsal cuneiform (angle of 30 to 40 degrees) and congenital metatarsal varus of case described (angle of 53 degrees right and 83 degrees left).

Dr. Edouard Papin reported two cases of congenital absence of the femur, but as in most reported cases these did not represent a complete absence (two out of eighty-three reported cases). These two illustrated two varieties, one in which the shortening of the leg was extreme and gradually increased during growth; the other with a less increase of shortening during growth. This latter case showed a condition of the head of the femur which suggested an intra-uterine fracture, whereas the other structures of the leg were normal.

Dr. J. Gourdon reported a case of a coxa vara of hypothyroid origin. The condition is not a simple weakening of the femoral neck, but is a complex affection, anatomically, pathologically, and mechanically. He reports a case of a patient fifteen years of age with a marked right coxa vara and genu valgum, obesity, and with an adipose genital syndrome. The x-ray showed separation of the epiphyseal cartilage and a lowering of the head. The articular line was soft, the neck curved, with anterior torsion. The left hip showed no deformity, but clinically was painful, and the articular line showed roughened areas. He emphasizes the necessity of recognizing the conditions which develop a tendency to this affection, and urges early treatment and redressment when necessary.

Dr. H. L. Rocher and Dr. G. Ouary presented two cases of congenital rigidity of joints which evidently were consequent to malformation of the skeleton, with muscular dysplasias and muscular aponeurotic contractures.

Dr. Massé and Dr. Chassaigne showed a case of osteoperiostitis following closely a trauma with a contusion of the right knee without open wound, developing a phlegmon after three days, which required opening. Following this was a bronchopneumonia and an osteoperiostitis at the level of the lower third of the face of the right tibia. As an industrial case, this involved the important question as to the relation of the trauma and the osteoperiostitis. The majority of writers admit the connection between these two when osseous infection follows the injury rapidly (five to fifteen days), when the trauma has been violent, and when the symptoms, particularly pain, have been present in the interval. The insurance companies have accepted this theory.

Dr. H. L. Rocher and Dr. G. Roudil presented a marked spondylolisthesis without functional disturbances. They give the case of a young man active in sports and games, who showed a flexible spine. The appearance of the back suggested a shortening of the lumbar spine. The x-ray showed a marked degree of displacement of the fifth lumbar and sacrum. The fifth lumbar appeared nearly vertical, there were atypical lumbosacral articulations, the sacrum was nearly horizontal, and the inferior portion malformed. The abnormal condition in this case was entirely compatible with a very large degree of physical activity.

Dr. P. Forton showed a fracture of the tarsal scaphoid. He considers the important position of the scaphoid as the key in the vault of the arch, and believes that it should not be left unsupported in the treatment of these fractures. He advises the application of a carefully fitted plate, which should be worn for several weeks, this treatment combined with physiotherapy.

Current Literature

ORTHOPÄDIE IM KINDESALTER (ORTHOPAEDICS IN CHILDHOOD). By Hofrat Prof. Dr. Hans Spitzy, Vienna, with the collaboration of Geh. Hofrat Prof. Dr. Fritz Lange, Munich. Ed. 3, Leipzig, F. C. W. Vogel, 1930.

A work on the orthopaedics of childhood could have been developed in no finer laboratory than the active modern hospital of Prof. Spitzy in Vienna. A new edition of this work furnishes the surgeon with the latest theories and unique methods evolved in this atelier but ever maintains its balance by presenting a composite of contemporary opinion.

The discussions of the etiology of congenital deformities are excellent. Without overlooking the rôle of secondary mechanical factors, the writer has correlated the manifestations of embryonic malformation in such a way as to leave no doubt as to the importance of developmental aberration. An unusual challenge is issued to the orthopaedic surgeon to prevent the intermarriage of individuals with hereditary physical defects. Quaintly enough, in almost the same breath, the physician is urged to develop the physical perfection of his charges, inspired by the possible inheritance of acquired characteristics.

Improvement of posture becomes a religion. Infants are allowed the prone position and creeping. Sitting and walking are carefully restricted. School children are observed at their desks and at play. A detailed classification of sports emphasizes the influence of each one on the growing child.

The chapters on club-foot, congenital dislocation of the hip, and chronic joint disease are particularly well done. The very early treatment of all deformities is advocated. Fusion of tuberculous spines is not discouraged as one would expect in an Austrian book. It is performed only in the third year of the disease, however, when convalescence is well established. Unusual is the functional treatment of flat-foot and other postural deformities. A knob or button is so placed that it reminds the slouching child in no uncertain terms of his relaxed attitude. Different from the American and English practice is the treatment of early residual poliomyelitis by electrical stimulation instead of muscle training. The acceptance as final of the paralysis which exists at the end of one year is indicative of the Continental attitude. The reestablishment of muscle balance by the frequent early transplantation of tendons is also characteristic.

Prof. Fritz Lange has contributed a chapter on deformities of the spine which is excellent in itself but rather interrupts the organization of the book. The mechanics of posture are well explained but from the clinical side some duplication is introduced. An outline of Prof. Lange's active exercises is valuable. The discussion of scoliosis is brief, with supplementary references. It is largely a summary of the methods of one school. To Abbott and Galeazzi are allotted an additional eight lines.

A section on surgical technique and anaesthesia in childhood contains valuable information. Avertin is recommended after a large experience with its use. Supplementary chapters on plaster technique and physiotherapy serve to round out the volume. A convenient plan of organization, marginal headings, and comprehensive bibliographic notes recommend the book for reference work. Diagnosis and indications are stressed for the benefit of the pediatrist and general practitioner. The bone and joint surgeon may well study the work carefully, not only for the original material contained, but for the concise statement of the modern concept of "orthopaedics" in its literal sense.

It is greatly regretted that the April number of **The Cripple** is to be the farewell issue, and *The Journal* takes this opportunity to express the appreciation of the part which it has played in this much neglected but very important field, and of the influence

it has already wielded in awakening the realization and the enthusiasm which is gradually being developed in different parts of the world. No one journal has done more to awaken the public conscience toward human wastage, and to suggest ways and means to avoid this wastage.

In the farewell number, the article entitled "Civilization and the Cripple", by Frederick Watson, the Editor, and which is now published in book form, should be read by orthopaedic surgeons and by all lay workers who are engaged in this work. Mr. Watson demonstrates in this article his wide experience, his scholarship, and his literary style. The chapters on "The Historical Background", "The Influence of the War on the Cripple", "The Education and Training of the Cripple", "The American Scheme", "Prevention and Rehabilitation", and "Limitations of Social Service" contained in this volume present unusual and valuable information on this wide subject.

The problem of the crippled child may be considered to be in the way of solution, but the problem of the adult cripple, as Mr. Watson shows, is perhaps more important, both economically and socially, and the lines of its solution are much less clearly defined.

"Civilization and the Cripple" will be available by application to the International Society for Crippled Children at Elyria, Ohio. We would urge a very general reading of this book, as well as the many publications on these subjects which have come from Mr. Watson's pen.

LE COXOPATIE DEFORMANTI E LE IDÉE DEL CALOT. A PROPOSITO DI 12 CASI DI OSTEOCONDRITE DEFORMANTE INFANTILE DELL'ANCA. By Dr. Mario Buisson. Torino, Arti Grafiche L. Giachino, 1929.

Buisson studied deforming osteochondritis of the hip in twelve cases, particularly in reference to the theory of Calot in relation to congenital luxation. The problem must be viewed from the evidence of the x-ray, for, as stated by Mouchet, the clinical evidence is practically negative.

He concludes (1) that in all the deforming coxopathies, the fact of the subluxations as described by Calot can be demonstrated, and (2) that among the different types of deforming coxopathies in children and in adults there is no essential difference but only the difference of the degree in the initial period. Through a long series of cases the intermediate steps can be traced to the extremes of the morbus coxae senilis.

The Journal wishes to acknowledge the receipt of the following publications sent to the Editorial Department:

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Of special interest in this issue are the papers on "Pathogénie de l'Ostéite Infectieuse", by Stanislas Nowicki, and "Traitement aux sels d'Or de la Tuberculose Osseuse et Articulaire", by J. Krotoski.

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Die physiologische und skoliotische Drehung der Wirbelsäule. F. Heuer. Zeitschrift für orthopädische Chirurgie, Vol. LII, p. 513, 1929.

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*To be reviewed in a later issue of *The Journal*.

Über die Indirekten Brüche des Tibiakopfes nebst Beiträgen zur Röntgenologie des Kniegelenks (Indirect Fractures of the Head of the Tibia with Contributions to the Roentgenology of the Knee Joint). Olle Hultén. *Acta Chir. Scandinavica*, LXVI, Supplement XV, 1929.

By a large series of contour tracings of x-rays of the knee joint it is shown that the size and shape of the lateral tibial tubercle and its relationship to the lateral femoral condyle vary greatly. With the knee in extension the lateral tibial spine lies under the femoral condyle and may in extreme cases be well under it. There is a corresponding excavation of the condyle of varying depth. The tubercle may be irregularly developed and have several points. It is shown also that the densest cancellous bone of the femoral and tibial condyles and the thickest joint cartilage are on the lateral side of the joint.

Experimental injuries were produced in eighty knee joints and then studied by x-rays and direct inspection. The amounts of bony and ligamentous injury were usually indirectly related to each other. There was a characteristic fracture and ligamentous tear for strain of the knee in hyperabduction, adduction and extension. Sometimes the ligamentous injury could be diagnosed roentgenologically by the accompanying chip fracture. The relative number of such diagnoses is expressed in per cent.

Seventy-six clinical fractures of the head of the tibia are divided into longitudinal and compression fractures, and subdivided according to location and frequency. The causes and resulting types of injury are fully tabulated. Forms of treatment and results are given in detail. It is concluded that in the longitudinal fractures an exact anatomical reposition is not necessary. Open operation shou'd be resorted to only when repeated attempts at closed reduction are unsuccessful. Deep cup-shaped depressions of the tibial head, on the other hand, lead to extreme disability. They can be reduced only by open operation and should be so treated at once.

A review of thirty-five cases averaging five years following fracture of the tibial head showed that recovery was very gradual and that after three or four years progressive improvement was still to be observed. The end results were better than is universally believed. In most of the longitudinal fractures of either or both condyles a complete

restitution of function was obtained. In many of those with disability, the loss of function was due largely to ligamentous injuries. Greater disability was caused by displacement of the medial than the lateral condyle.

Exostoses about the joint surfaces were frequent in longitudinal and rare in compression fractures. There was no relationship between the size of exostoses and function. No case of secondary deforming arthritis was observed.

A review of such a detailed study as that of Hultén can present only a few of the many significant findings. Ninety-one colored and thirty uncolored tracings, sixty-five reproductions of roentgenograms, and numerous tables, make the material easily assimilable. A detailed history of the ninety-one cases and an extensive bibliography complete this valuable contribution to the literature of fractures.—*W. P. Blount, M.D., Milwaukee, Wis.*

PRIMARY HEMANGIOMA OF BONE, WITH SPECIAL REFERENCE TO ROENTGENOLOGIC DIAGNOSIS. P. C. Bucy and C. S. Capp. *Am. J. Roentgenol.*, XXIII, 1, 1930.

The authors present eight cases of hemangioma of bones. The x-ray of the case in which the dorsal vertebrae were involved showed a distinct mottled appearance of the bodies. The trabeculations of bone were three times their normal size with loss of normal homogeneity and with vertical parallel striations. Some of the trabeculations extended into pedicles. The intervertebral discs and bodies were otherwise unchanged. This patient had symptoms of compression myelitis, so laminectomy was performed and hemangioma cavernosa diagnosed.

Other cases of the scapula, ilium, clavicle, ulna, and tarsal scaphoid are reported. The histories are of slow growing tumors with symptoms due to pressure. Operations were usually performed, followed by x-ray therapy.

The x-ray findings were: (1) a tumor breaking through the cortex, raising the periosteum but not breaking through it; (2) "sunburst" or central radiating trabeculae of bone. In differentiation,—a giant-cell tumor produces an expansion of the cortex of the tumor and no new bone formation within, while hemangiomas, as a rule, erode the cortex and grow subperiosteally. In addition, numerous fine trabeculae are seen. In early osteogenic sarcoma where the cortex is intact there is always a loss of bone density as compared with the hemangioma in which numerous fine trabeculations are present.

When the sarcomas pass beyond the cortex they produce numerous fine bony spicules but these do not radiate from a common center.

Microscopically, mitotic figures are never seen; clinically, the tumors are never malignant. The authors suggest excision if possible, with radiation. Preparations for hemorrhage must be made.

Most of the cases reported recovered or improved.—*C. S. Lowendorf, M.D., Iowa City, Iowa.*

OBSTETRICAL PARALYSIS. Paul N. Jepson. *Ann. Surg.*, XCI, 724, 1930.

History, etiology, pathology, and symptoms are discussed. Treatment first by prophylaxis, then brace and massage, and finally operative. Repair of the brachial plexus by suture has been disappointing. Correction of deformity in old cases gives satisfactory improvement.

Conclusions: (1) Obstetrical paralysis should be treated as an orthopaedic condition and all deformity carefully observed and prevented; (2) the shoulder should be put in plaster at once, holding it in ninety degrees abduction, ninety degrees external rotation, forearm flexed and supinated; (3) in most cases the injuries to the nerves are not severe and if treated early will tend to recover; (4) relaxation and dislocation of the shoulder are secondary lesions; (5) when deformity of internal rotation and hyperextension of the elbow exists, a rotation osteotomy is advisable and usually suffices to give function; (6) patients suffering from obstetrical paralysis should be under observation until the age of ten, for fear of a persistence of slight deformity.—*Fred G. Hodgson, M.D., Atlanta, Ga.*

Operative Treatment of Compression Fractures of the Calcaneus. R. Simon and E. Stulz. *Ann. Surg.*, XCI, 731, 1930.

Prognosis in these fractures is bad, owing to the fact that reduction is not effected. The superior articular surface of the os calcis is crushed down into the cortex and the subastragaloid joint is disturbed. Traumatic arthritis of this joint develops and is the main cause of pain and disability. This disturbance of the joint surface can be corrected only by open operation, reduction, and fixation. Operation is by an external submalleolar incision, replacing the bone fragments so as to restore the articular surface, and fixation by metal brad. The peronei tendons are cut and resutured, with fixation by a gutter case which is worn about six weeks. Four weeks later walking with two sticks. Eight cases are reported, with radiograms. Subastragaloid arthrodesis is advised for cases with persistent pain.—*Fred G. Hodgson, M.D., Atlanta, Ga.*

Treatment of Fracture of the Neck of the Femur in the Aged. J. E. Cannaday. *Ann. Surg.*, XCI, 750, 1930.

These cases are treated in a plaster spica from toes to nipple line and down to knee on the sound side. Position of fractured leg is: knee flexed to ninety degrees, hip flexed to ninety degrees, and thigh abducted and internally rotated. The author calls it a sitting Whitman position. A fracture table is necessary to apply such a cast. A spreader bar extends between the thighs. The patient is allowed to sit up or turn in prone position as often as desired, or the position is changed frequently by the nurse. The knee is freed at the end of six weeks, the remainder of the cast seven or eight weeks later. No stiffness of knee or hip joint, no pneumonia or bed sores have occurred.—*F. G. Hodgson, M.D., Atlanta, Ga.*

The Management of Fracture of the Femur. D. Goldblatt. *Ann. Surg.*, XCI, 739, 1930.

These cases were grouped and classified according to displacement, location, age, sex, etc. Under treatment, the following headings are given: time of reduction; correct coaptation; compound fractures; use of non-absorbable material; articular cavity; nonunion; repair. Fracture of the neck of the femur is discussed. For fracture of the shaft with any overlapping, Steinmann pin skeletal traction is used. A follow-up and grading is reported on twenty cases.—*F. G. Hodgson, M.D., Atlanta, Ga.*

Weitere Versuche über die Transplantation der Knorpelfuge (Further Experiments on Transplantation of Epiphyseal Cartilage). Th. Fohl. *Arch. f. klin. Chir.*, CLV, 232, 1929.

Two types of experiments, on rabbits, were carried out:

1. Transplantation of the epiphyseal cartilage, including a piece of the diaphysis. Line of severance on the epiphyseal side at the border between cartilage and epiphysis.

2. Transplantation of epiphyseal cartilage, including the epiphysis. Line of cleavage on the diaphyseal side at the border between epiphyseal cartilage and diaphysis.

3. Supplement of these two groups by control series on a larger animal (an ape).

The conclusions drawn from these experiments were as follows: arthroplastic cartilage transplantation is successful not only when the epiphyseal disc alone is transplanted, but also when a portion of the diaphysis is transplanted together with the epiphyseal disc; or if the epiphyseal disc with the epiphysis is transplanted, regeneration of the epiphyseal disc and restoration of growth is possible within practical limits. It is, therefore, sufficient if one of the two surfaces of the transplanted disc enters into nutritial connection with a new matrix. The experiment on the monkey substantiated the results found in the rabbits. On the clinical side, the transplantation of the disc with a larger or smaller piece of the diaphysis to supplant a lost epiphyseal disc will come into consideration more often than the transplantation of the disc alone.—*A. Steindler, M.D., Iowa City, Iowa.*

FALGEN UND BEHANDLUNG GROSSER DEFEKTE DER KNIEGELENKSKAPSEL (RESULTS AND TREATMENT OF LARGE DEFECTS OF THE KNEE-JOINT CAPSULE). Fritz Kroh. *Arch. f. klin. Chir.*, CLV, 365, 1929.

Experimentation on two rabbits and ten dogs was carried out, with operative substitution of the capsular defect by the suprapatellar pouch in a case of comminuted fracture of the patella.

Conclusions: The synovial membrane is capable of covering smaller artificial defects by proliferation. The author found, after resection of the patella, the defect restored, thanks to the high degree of regenerative ability of the neighboring tissues. After the injury to the synovial lining is produced, the first reaction is that of the vascular apparatus of the synovia, and only secondarily by combined action of the reactive hyperaemia and the secondary reaction of the synovial structure there are histological changes in the synovial lining. The experiments teach that the cartilage and bone defects after injuries entail only quantitative losses without secondary histological changes of the surrounding parts, but that the synovial and subsynovial tissues react to injury by increased growth and finally by transformation.—*A. Steindler, M.D., Iowa City, Iowa.*

BEITRÄGE ZUR FRAGE DER FREIEN AUTOPLASTISCHEN KNOCHENTRANSPLANTATION. EXPERIMENTELLE UNTERSUCHUNGEN MIT BESONDERER BERÜCKSICHTIGUNG DER TRANSPLANTATION FEINER KNOCHENSTÜCKCHEN UND-SPLITTER (CONTRIBUTION TO THE QUESTION OF FREE AUTOPLASTIC BONE TRANSPLANTATION. EXPERIMENTAL INVESTIGATION). S. I. Kartaschew. *Arch. f. klin. Chir.*, CLVI, 758, 1930.

Experiments were carried out in full grown rabbits,—altogether ninety-four experiments on seventy-one rabbits were performed. Transplantation was made as follows: in bone defect, with periosteum and bone marrow, simultaneously on both anterior extremities; transplantation of small pieces of bone without periosteum, but with endosteum and bone marrow; transplantation of fine bone pieces and splinters without periosteum and without bone marrow; transplantation of fine bone spicules with periosteum, endosteum and bone marrow; and finally, transplantation of fine small bone pieces without periosteum, endosteum and bone marrow.

The author draws the following conclusions: The healing of free autoplastically transplanted bone depends upon the presence of periosteum and endosteum; only through these structures an early vascular connection of the transplanted bone with the surrounding tissue and proliferation of newly formed blood vessels into the system of the haversian canal is possible. Small bone splinters which have better nutritional conditions from the beginning retain their vitality in their entire mass for a much longer time, in contrast with larger bone grafts or whole sections of the diaphyses which remain alive only in circumscribed portions. However, in spite of the survival of considerable sections and even total portions of pieces of bone, the transplanted bone finally succumbs after absorption with substitution by new bone, the absorption of small pieces occurring much more rapidly than the absorption of whole diaphyses, with more rapid substitution by new bone. This substitution of the old bone occurs directly and insidiously. Only at the time of the most intense bone formation, lacunar absorption by osteoclasts is observed. The main force of the bone formation in bone transplantation is the periosteum, the endosteum, and bone marrow. If single pieces of bone containing these elements are transplanted into the musculature of the back, they finally unite in a homogeneous solid bone mass, being transformed in their structure and forming a new type. When transplantation is carried out in complete defect of bone, the newly formed bone leads to the bridging of the defect and the complete restoration of the original form of the bone. This bone-forming power of the transplanted bone depends principally upon the nutritional conditions which are created. In this regard, transplantation of small bones offers great advantages. Especially favorable are the conditions for the transplantation of small bone pieces in regard to the endosteum and bone marrow. While in transplantation of whole diaphyseal sections the cellular element

in the marrow canal completely disappears, in the transplantation of small pieces of bone, these elements, due to the inundation of nutritional juices, remain alive and lead to intensive deposition of bone tissue. The same is true of the cellular element in the haversian canal: they remain alive, transplanting smaller bone chips, and then take part in the transformation of bone. Aside from the bone formation through these specific bone-forming elements,—namely, the periosteum and endosteum, and the cells of the haversian canal—there is also observed a metaplastic formation of bone through the surrounding young connective tissue. This metaplastic bone formation is directly dependent upon the character of the connective tissue, and therefore upon the rapidity with which the transplanted bone becomes absorbed. Therefore, in transplantation of small pieces of bone when the microbiosis occurs slowly and the activity of periosteum and endosteum is very great, the surrounding connective tissue retains for a long time its embryonal character, and becomes transformed by way of metaplasia into osteoid and bone tissue. In transplantation of old diaphyseal sections, however, the surrounding connective tissue is rapidly transformed into fibrillous tissue, and metaplasia under this condition occurs extremely rarely.

The author also finds that transplantation of fine splinters of bone with the powerful bone-forming activity of the osteogenetic elements, and the favorable condition for metaplasia of the surrounding connective tissue into bone, offers great advantages in operative interferences against the transplantation of larger pieces or whole sections of the diaphysis. It is, therefore, most commendable in cases of substitutional bone defects, and in cases of pseudarthrosis.—*A. Steindler, M.D., Iowa City, Iowa.*

Über die primäre akute und subakute Osteomyelitis purulenta der Wirbel (Primary Acute and Subacute Purulent Osteomyelitis of the Vertebrae). G. Borchers. *Arch. f. klin Chir.*, CLVIII, 168, 1930.

Three cases are reported, with extensive tabulation of the literature. Staphylococcus aureus is, according to Lexer, who first reported on it, the principal infective agent. However, staphylococcus albus, streptococcus and pneumococcus have been found. As ports of entry, furuncles, carbuncles, panaritia, abscessed teeth, stomatitis, and even mastitis are being mentioned.

Osteomyelitis of the neural arches and their processes is mentioned in fifteen cases of the literature; the osteomyelitis of the bodies embraces sixteen cases; in seven, a combination of arch and body involvement is mentioned. In eleven cases there is no data on the seat of the focus. The author considers the well known complications arising from extension of the osteomyelitic process from the spine to the neighborhood: meningitis, phrenic nerve involvement, cord compression, mediastinal abscess, psoas abscess, and peritonitis. He points out the rarity of gibbus formation and scoliosis. In his series of forty-eight cases, collected in the literature and including his own, he finds only six cases with subacute course, while in Volkmann's collection eighteen cases with subacute course are registered. The general symptoms are discussed, attention being called to the occasional absence of percussion pain, to the engorgement of cutaneous veins, the meteorism, and the tenderness of the anterior surface of the bodies on palpation through the abdominal wall. He points out further the failure of x-ray diagnosis—if in the first and second weeks differentiation from tuberculosis of the spine is difficult from the x-ray findings. The complex problem of differential clinical diagnosis is considered principally in relation to tuberculosis, typhoid, and meningitis.

The author considers the prognosis, in general, very grave,—twenty-seven of the forty-eight cases in his collection ended fatally. The total mortality is given in the literature variously from forty-one to seventy-one per cent. It seems that the outlook depends greatly upon the virulence of the bacterial agent, upon the individual resistance, and upon localization and distribution of the disease in the spine.

The author's view on the treatment is, in general, in accord with the current opinions. It is preeminently surgical. Incision of the osteomyelitic abscess is imperative. Drainage is sufficient in superficial bone lesions. Perforation into the spinal canal necessitates

laminectomy. Retropharyngeal abscesses are approached from the lateral triangle of the neck behind the sternocleidomastoid muscle. Thoracocentesis is done in extensive empyema. The costotransversectomy for evacuation of retromediastinal accumulations is not mentioned. For psoas abscess, wide opening as for ligation of common iliac artery is recommended.—*A. Steindler, M.D., Iowa City, Iowa.*

CALLUSBILDUNG UND SÄUREBASENGLEICHGEWICHT (CALLUS FORMATION AND ACID-BASE EQUILIBRIUM). E. Kubányi. *Arch. f. klin. Chir.*, CLVIII, 203, 1930.

Experiments were carried out on 135 animals,—guinea-pigs or rabbits. Guinea-pigs were treated one, two, or three weeks with alkali,—*i.e.*, ingestion of twelve cubic centimeters of eight per cent. sodium bicarbonate solution; guinea-pigs treated with acid for one, two, or three weeks,—*i.e.*, ingestion of twelve cubic centimeters of one-tenth normal hydrochloric acid solution. The same series of experiments were carried out on rabbits.

It was found from the pathohistological studies of the callus which was formed after experimental fractures, that the healing process in the callus of animals treated with alkali is in the first two or three weeks more intense than in the control animals treated with acid. This difference in favor of the alkali-treated animals was peculiarly restricted to the first weeks, —*i.e.*, to the time in which callus consists largely of connective-tissue granulations. But from the end of the third week on the difference seems to turn in favor of the acid-fed animals, at least so far as the density of the newly formed bone is concerned. The very first stage of callus formation consists in connective tissue in which the dominant reaction is alkaline. By alkaline reaction, the swelling of the tissue colloids is increased and the higher water content hastens the growth of tissue; acid reaction, on the other hand, decreases the viscosity of the tissue and the water withdrawal retards tissue growth or even produces tissue disintegration. This, according to Balint, explains the fact that the first stage of callus formation is more intensive in the alkalined animals. But when the stage is reached where calcium deposit begins, the situation is reversed and the callus of the acid-fed animals preponderates. This seems to tally with the observation of Balint, that in experimental tuberculosis calcification of the focus begins earlier in the acid-fed animals than in the alkalined controls.—*A. Steindler, M. D., Iowa City, Iowa.*

DIE ROLLE DES VITAMINS D FÜR DIE REGENERATION DES KNOCHENGEWEBES UND DIE CALLUSBILDUNG BEI EXPERIMENTELLEN FRAKTUREN (THE RÔLE OF VITAMIN D FOR THE REGENERATION OF BONE TISSUE). J. A. Collazo, P. Rubino, and B. Varela. *Arch. f. klin. Chir.*, CLVIII, 214, 1930.

The authors' experimental findings relate to active reparative processes in bone fifteen and twenty-five days after artificially produced fracture. The vitaminized animal showed greater amount and greater density of the callus with high calcium deposit, increase of cartilage tissue, and greater calcification tendency of the newly formed embryonal tissue. In the rachitic animal, on the other hand, embryonal connective tissue and newly formed fibrous tissue prevailed, which explains the greater translucency of the callus in the x-ray picture. In a later period,—*i.e.*, after twenty-five days—the acceleration of callus formation and the early regression of the fibrous callus are especially marked in comparison with the rachitic animal. Furthermore, in contrast with the normal and the rachitic animal, the vitaminized animal shows at the site of the fracture a marked reabsorption of bone, which indicates a process of mobilization of bone elicited by the vitamin diet. On the strength of these observations the authors recommend the use of vitamin D in the treatment of fractures.—*A. Steindler, M.D., Iowa City, Iowa.*

Über die Innervation der Kapsel und der Epiphysen des Kniegelenks (Innervation of Capsule and Epiphyses of the Knee Joint). A. G. Jeletzky. *Arch. f. klin. Chir.*, CLVIII, 237, 1930.

The anterior median half of the knee joint capsule is supplied principally by a small branch of the nerve for the vastus internus. Also, the saphenous nerve and the obturator nerve share in the innervation of this portion. At the internal condyle of the tibia and at the internal lateral ligament, a small branch from the tibial nerve, coming forward from the popliteal fossa, is added to the nerve supply. The anterolateral half of the knee joint capsule is supplied mainly by small branches from the external popliteal nerve. In this supply, small nerves from the vastus externus muscle likewise take part. The vastus intermedius nerve sends fibers for the supply of the periosteum of the anterior third of the femur and the adjacent portion of the joint capsule. The median portion of the periosteum in the lower femur is supplied by the nerves from the vastus internus, the lateral portion from branches coming from the supply of the vastus externus. The posterior medial portion of the knee joint capsule is supplied by branches from the posterior tibial and obturator nerves, the posterior lateral portion of the joint gets its innervation from branches of the external popliteal and tibial nerves.

Branches of the posterior tibial accompany the arteria articularis genu medialis, the articularis genu inferior medialis and lateralis, branches from post tibial and obturator accompany the arteria genu media, and branches from the external popliteal the arteria genu superior lateralis. All these nerves enter with the arteries into the posterior portion of the knee joint and into the interior of the joint itself, supplying also the posterior portions of the epiphyses of femur, tibia, and fibula. Branches from these three nerves supply not only the posterior capsule and epiphyses but also the vessels of the popliteal fossa.

The densest plexus is in the popliteal fossa toward the knee joint, where the arteria genu media, and the arteria articularis genu inferior medialis arise from the popliteal artery. Here the author found pin-head-sized nodes, which on microscopic examination proved to be ganglion cells. Pacini bodies are found in abundance in all ramifications of the arterial nerves of the popliteal fossa. In the upper portion of the popliteal fossa, arteries and veins are innervated by the saphenous and obturator nerves, so that the vascular innervation of the popliteal fossa is furnished by all three,—*i.e.*, nervus sciaticus, nervus femoralis, and nervus obturatorius.—*A. Steindler, M.D., Iowa City, Iowa.*

Über Brüche des 1. Mittelhandknochens und ihre Behandlung (Fractures of the First Metacarpals and Their Treatment). Walter Ehalt. (From the Böhler Clinic in Vienna). *Arch. f. Orthop. u. Unfall-Chir.*, XXVII, 515, 1929.

The author considers two conditions. First, the so called Benett fracture, and then the other fractures of the first metacarpals. The Benett fracture was first described by Benett in 1881 and is an oblique or chip fracture of the base of the first metacarpal. In the eleven cases reported, this fracture occurred by indirect violence by striking the head of the first metacarpal. The fracture, however, can also be produced by direct violence to the first metacarpal, as when it is forced toward the palm of the hand. The volar and ulnar side of the metacarpal base is fractured off, and the subluxation occurs either directly or subsequently by muscle pull. The treatment as practised in Böhler's clinic is as follows: First, reposition,—the thumb is grasped from the dorsal aspect; the operator's index finger abducts the head of the first metacarpal and then extends. His own thumb presses directly upon the base of the metacarpal in radiodorsal direction, that is, opposite to the direction of dislocation. By this manoeuver, the dislocation is relieved; usually a distinct clicking is heard when this occurs. The extension is for the purpose of correcting the longitudinal displacement of the metacarpal, while abduction and pressure upon the bases produce good apposition and proper rotatory position of the fragments. The position is maintained as follows: Dislocation or subluxation without fracture, or Benett fracture without subluxation, or those with subluxation in which only the extra-articular process or a very small portion of the articular surface is fractured

off, are simply taken care of by a plaster splint. To all others, that is, those in which there is a considerable portion of articular surface fractured off, wire extension is added. A plaster splint is applied directly upon the skin on the dorsal side of the forearm, reaching from the elbow to the slightly dorsally flexed wrist and on to the heads of the second to the fifth metacarpals. At the distal end of the splint a short longitudinal cut is made, about four fingers in width, and the edges are remodelled around the first metacarpal reaching to the interphalangeal joint of the thumb. Then, while the cast is still soft, reposition in abduction, as described, is carried out and this position is maintained until the plaster has hardened.

Aside from the eleven Benett fractures, the author reports twenty-six cases of fracture of the first metacarpal; basis fractures, ten; oblique fractures without involvement of the joint, three; interarticular Y-shaped fractures, one; fractures of the shaft, five; comminuted fractures, two; and fractures of the head, three.

In the treatment, the following policies were followed: Fractures of the first metacarpal that show no primary displacement and where there is no danger of secondary displacement, are treated as usual with finger splints and plaster casts. The splint is applied in slight dorsal flexion, the thumb being in middle position. It is then fastened with a muslin bandage and covered by a plaster splint, which reaches from the terminal phalanx of the thumb to the elbow.

In cases in which there is displacement, there is added extension with rustless steel wire applied under local anaesthesia (2 per cent. novocain), this being the same method as that used in the Benett fracture as described before.

Compound fractures are treated by careful excision of the wound, removal of bone splinters, and then by the same method of the finger splint and plaster splint.—*A. Steindler, M.D., Iowa City, Iowa.*

ZUR ANATOMIE DES ANGEBORENEN UND DES PARALYTISCHEN HACKENFUSSES (ANATOMY OF THE CONGENITAL AND PARALYTIC PES CALCANEUS). W. Kniepkamp. *Arch. f. Orthop. u. Unfall-Chir.*, XXVII, 551, 1929.

This is a very extensive and thorough anatomic examination of these two deformities.

The untreated congenital calcaneus develops with the beginning of the walking function into a flat-foot; there is a pronatory displacement of the os calcis against the astragalus which, according to measurements, amounts to about twenty-five degrees. From joint mechanical considerations, the author believes that the changes in the different joint positions do not necessarily mean a morphologic change of the bone.

In the acquired paralytic valgus, there are osseous changes similar to those seen in valgus and varus deformities, but these seem to be confined to the immediate neighborhood of the articular surfaces.—*A. Steindler, M.D., Iowa City, Iowa.*

ZUR HISTOLOGISCHEN UNTERSCHEIDUNG ECHTER RIESENZELLENSARKOME VON RIESENZELLREICHEN AUFSAUGUNGSGESCHWÜLSTEN AM KNOCHEN (HISTOLOGICAL EXAMINATION OF TWO GIANT-CELL SARCOMAS). F. Schroeder. *Arch. f. Orthop. u. Unfall-Chir.*, XXVII, 596, 1929.

The author goes into the histologic differentiations between giant-cell tumor, which he classifies as an absorption tumor, and true polymorphous giant-cell sarcoma. There are certain differences between the two tumors. The stroma of the two different formations consist in a very vascular tissue in which the vascular endothelial cells are transformed into the characteristic tumor cells. The giant cells of the polymorphous type sarcoma also can be traced to the endothelial cells of the vessel as can the giant cells of the giant-cell tumor. The histogenesis of the giant cells is, therefore, not proof of malignancy or benignity of the tumor formations.—*A. Steindler, M.D., Iowa City, Iowa.*

THE SUN CURE AND THE WORK CURE IN SURGICAL TUBERCULOSIS. Auguste Rollier. *British Med. J.*, II, 1206, 1929.

Rollier discusses briefly the results of his twenty-five years' experience with heliotherapy in the treatment of surgical tuberculosis. Without entering into specific details, he paints in broad outline the happy results which have followed the introduction of heliotherapy as the chief agent in the treatment of bone and joint tuberculosis, and contrasts these with those formerly obtained by surgical methods. The general consensus of opinion of orthopaedic surgeons is in agreement with his conclusions but some of his explanations and statements fall strangely on critical ears. For example, in interpreting the means whereby sunlight cures tuberculosis, he states, "This may be explained partly by the improvement in capillary circulation and possibly also as a result of the vibratory impact caused by the sun's rays on the network of sensory nerve endings in the skin". Again, speaking of its effect on local lesions, "In many closed cases sequestra gradually absorb or more often they become organized and incorporate themselves again with the living bony tissue". Nevertheless, though one may find it difficult to follow Rollier in his explanations, his results are impressive and have now been confirmed by the experience of many other surgeons.

The value of heliotherapy is accepted—but the importance of work as an adjunct is only beginning to be recognized. The most interesting part of Rollier's paper is his description of the work cure as carried out at Leysin. The word "cure" is not used in its ordinary sense, since the work in which the patients engage plays no part in the actual cure of the pathological foci from which they are suffering. It does, however, occupy the patient's mind during the long months of his treatment and, when properly organized can be utilized to ease his economic burden. It has reached its most successful development in the recent establishment of a factory clinic of 120 beds. Here indigent patients will benefit by a modern technical organization and will have an opportunity of earning their livelihood by easy and remunerative work while continuing their solar treatment. The establishment will have the dual character of factory and clinic. The wards and balconies are fitted up as workshops fully exposed to sun and air. Patients confined to bed will have at their disposal upon a table attached to each bed very complete and specially adapted appliances worked by electricity. They will make pieces of small mechanism, such as parts of watches. A whole floor is devoted to an international school of commerce. Foreign languages will be taught. As planned, it is hoped that the factory clinic will be a useful contribution to the difficult social problem involved in treating indigent patients suffering from surgical tuberculosis. The experiment will be watched with interest.

Rollier's paper is the subject of editorial comment in the same number of the *British Medical Journal*.—*R. I. Harris, M.B., Toronto, Canada.*

UNION AND NON-UNION OF FRACTURES. A. S. B. Bankart. *British Med. J.*, I, 8, 1930.

Bankart advances the new and somewhat revolutionary idea that the presence of hemorrhage is essential to the union of fractures and that its absence (a dry fracture) is the cause of non-union.

Limiting his discussion to fractures of the neck of the femur in elderly people, he states that the commonly given causes of non-union are not correct. Great separation of the fragments or the interposition of soft tissues, he admits, may mechanically prevent union, but he ridicules the idea that imperfect immobilization plays any part in causing non-union. Among the constitutional causes of non-union (syphilis, gout, chronic nephritis, diabetes), he points out that many are associated with arterial disease and it is this latter, he supposes, which causes the non-union by preventing adequate hemorrhage. The reasons he advances for his belief in the power of hemorrhage to stimulate bone repair are few and are scarcely convincing. He criticizes the common forms of treatment of fracture of the neck of the femur (open pegging and Whitman abduction) as being procedures of such magnitude as to be dangerous, and as being uncertain in their results.

The author gives the case history of one patient, aged fifty-seven, suffering from an intracapsular fracture of the neck of the femur, successfully treated by the injection of fourteen cubic centimeters of blood into the hip joint and skeletal traction. The hip was not fixed. Traction was maintained for six and one-half weeks. The patient walked in a caliper at the end of nine weeks and discarded this after an indefinite period. Solid bony union in excellent position was obtained.

Excellent reproductions of the radiographs illustrate the article.—*R. I. Harris, M.B., Toronto, Canada.*

A Reversible Bed Frame for Spinal and Other Cases. E. W. Hey Groves. *British Med. J.*, I, 66, 1930.

Hey Groves describes a special bed suitable for the complicated nursing of patients with spinal fractures and similar conditions. Its essential features are two paired mattresses which are split longitudinally, held in a box bed which can be rotated through 180 degrees about its long axis. With this device the patient can be turned on his face with ease and comfort.—*R. I. Harris, M.B., Toronto, Canada.*

Kümmell's Disease. S. Watson Smith. *British Med. J.*, I, 109, 1930.

Smith reports the history and physical findings of a case of spinal disease which he regards as Kümmell's disease. The patient suffered an injury by falling six feet onto the back of her neck. The immediate disability was slight and was soon recovered from. Eleven years later she sought treatment for numbness, tingling, and pain in the hands and weakness of the hand and forearm. X-ray showed caries of the sixth and seventh cervical bodies. The von Pirquet tuberculin test was negative.—*R. I. Harris, M.B., Toronto, Canada.*

Osteitis Deformans: Treatment by Ultra-violet Rays. Clement Necory. *British Med. J.*, I, 492, 1930.

After discussing the pathological changes in the bone in Paget's disease, Necory relates his experience with four cases of this condition treated by ultra-violet radiation from a quartz mercury lamp. Case histories of two are given and two others are briefly mentioned. All were symptomatically improved by ultra-violet light, and x-rays are stated to show remarkable reconstruction of bone. The article is illustrated by two radiographs of one of the cases, but the reproduction of these is so poor that no conclusion can be drawn from them.—*R. I. Harris, M.B., Toronto, Canada.*

Symmetrical Gangrene Complicating Rheumatoid Arthritis. Ralph Brooke. *British Med. J.*, I, 493, 1930.

Brooke records the case history of a patient who was admitted to the hospital eight years after the onset of rheumatoid arthritis, with symmetrical gangrene involving all four extremities. The arthritic changes were marked and advanced pulmonary tuberculosis was present. The left hand and both feet were amputated. Examination of the vessels showed an obliterating endarteritis.—*R. I. Harris, M.B., Toronto, Canada.*

Traumatic and Other Affections of the Knee Joint. H. A. T. Fairbank. *British Med. J.*, I, 581, 1930.

Fairbank discusses briefly the diagnosis and treatment of a variety of conditions in the knee joint. The salient features of his paper are as follows:

Synovitis: This results from minor injuries to the synovial membrane. He stresses the importance of *early active* movement and of faradic stimulation of the quadriceps group of muscles. He condemns treatment by rest and splinting.

Adhesions: These can be avoided by early and persistent movement. If of short duration, they can be overcome by persistent physiotherapy. If of longer duration, they must be broken down under ether anaesthesia. The signs of adhesions are limitation of movement, with pain at the limits of the range of movement.

Strain of lateral ligaments: The internal lateral ligament is most frequently injured, and its upper end seven times more frequently than its lower. The author advises a lateral splint and rest for a few days, then walking with an inside lift on boot. This should be combined with faradic stimulation of the quadriceps group, particularly the vastus internus and sartorius.

Injuries to crucial ligaments: For early cases he advises fixation in extension. For severely damaged or late cases, he advises open operation by the method of Hey Groves and Alwyn Smith. Gallie's operation is not mentioned.

Semilunar cartilage injuries: After discussing the mechanism of their production, he stresses the importance of a typical history, though this is not always present. Treatment is by operation, which he prefers to carry out through a straight incision internal to the patella. This can be prolonged into Timbrell Fisher's incision if necessary. He advises against the split patella incision.

Loose bodies: These are traumatic in origin. The typical symptoms are momentary locking followed by effusion. Treatment is operative removal.

Drainage to articular cartilage: The author states this affection is common. He includes in this group the cases of osteochondritis dissecans, which he regards as due to injury to the internal condyle by the tibial spine.

Osteo-arthritis may predispose a joint to symptoms following minor injuries. The diagnosis usually is easy. Faradism is the most effective treatment, since this permits exercise of the muscles without moving the joint.

Osteochondromatosis of the knee and *cysts of the external semilunar cartilage* are briefly discussed.

Finally, *knee cases in childhood* are considered as a separate group. He regards the knee cases of childhood as falling into three groups characterized by (1), persistent or recurring synovitis; (2), clicking in the joint; and (3), recurring symptoms resembling those seen in semilunar cartilage cases in adults. The first group he regards as due either to toxic absorption from tonsils or to tuberculosis. He states that the presence of fluid is against tuberculosis. If the diagnosis is in doubt, he advises removal of a portion of the synovial membrane for diagnosis. Clicking knees indicate abnormalities of the cartilage and demand operation.

The leading editorial of this issue of the *British Medical Journal* is devoted to a discussion of Fairbank's paper.—*R. I. Harris, M.B., Toronto, Canada.*

L'Influenza dei Tendini sullo Sviluppo dei Nuclei di Ossificazione (The Influence of the Tendons upon the Development of the Ossification Centers). Giovanni Giuliani. *Chir. d. Org. di Movimento*, XIV, 243, 1929.

This work is entirely experimental and has for its scope the study of the atrophy of the ossification centers. It is amply corroborated by numerous radiographic and microscopic findings.

Inasmuch as atrophy of the ossification centers of the apophysis of the os calcis has been reported after forced traction upon the tendo Achillis, such traction has been considered as a factor in progressive retardation of the nucleus in the vicinity of tendons. The author has set himself the task of finding out whether the physiological tension of the tendon upon the bone is, in some way, connected with the growth of the epiphyses. In fact, it is presumed that such action of the tendons upon the ossification centers plays a part in the production of clinical pictures, and it is pointed out that the so called growth diseases of the skeleton,—for instance, Osgood-Schlatter's disease, or Köhler's disease—belong in this group. The study is not entirely new, since numerous authors have interested themselves with the question of the importance of muscle tension or tone upon bone formation. In later years Faldino, sectioning embryonic and animal

material at term, was able to demonstrate clearly the decisive influence which the muscular apparatus has upon the skeleton in its state of development.

The author has taken for his experiment rabbits, in which the Achilles tendon was interrupted by resection of this piece of tendon. The limb was thereupon put in a plaster cast. In his radiographic findings there was in evidence a progressive atrophy of the nucleus of ossification. The reason for this became evident when the histological picture was studied. The atrophy often does not only involve the epiphyseal nucleus but also the proximal regions of the body of the calcaneus itself. Histologically it was found that there were condensations of the columns of the cartilage. Then there was a diminution in the zone of calcification up to total disappearance, and finally profound alteration of the cartilage mass which is found broken and unequal, and there was formation of new connective tissue from the medullary spaces into the cartilage.

What is true for the ossification centers of the calcaneal apophysis is probably true for all ossification centers. There is diminution in the deposition of lime salts, the primary cause of which the author believes to lie exclusively in the suppression of the muscle action and of the stimulus of weight-bearing. As the absence of the activity of the tendo Achillis gives rise to an atrophy of the epiphyseal nucleus in the os calcis, it is equally certain that similar atrophy follows upon exaggerated action of the tendon upon the bone. In fact other experimental workers have shown that excessive action of the triceps of the leg upon the point of insertion at the os calcis occasions an arrest of the development of the epiphyseal nucleus. Therefore, a certain optimum of physiological pull seems to be necessary for the stimulation of the epiphyseal growth.

The author believes that these functions of muscle tone play a rôle in Schlatter's, as well as in Köhler's disease, though he admits infective agents may be at work as well as traumatic ones. In order to meet the objection that the atrophy of the ossification center may have been caused by the immobilization incident to the operation, the author compared findings in limbs which were operated upon as well as immobilized, with those that were immobilized only, with the result that, in the latter, retardation of the ossification center, although noticeable, was very much less marked.—*A. Steindler, M.D., Iowa City, Iowa.*

Processi Morbosi Primitivi della Capsula Articolare (Primary Pathological Conditions of the Articular Capsule). E. Venezian. *Chir. d. Org. di Movimento*, XIV, 266, 1929.

Contribution to the knowledge of cyst formation of the meniscus of capsular angioma.

Report of one case of cyst formation of the external semilunar cartilage.

Report of another case of a capsular hemangioma of cavernous type.

The author discusses primary tumors of the synovial membrane of the joint. Fibroma and lipoma are not uncommon. Less frequent are chondroma and especially the chondrosarcoma. A very rare formation is the osteoma which is mostly of the spongious type. The formations of vascular origin are the very rare angiomas and the still rarer endotheliomas and peritheliomas. Among the angiomas he distinguishes between the simple angioma and the cavernous type, the so called cavernoma which is the type of tumor which he describes in his case. It has a structure entirely similar to that found in the corpora cavernosa. The primary hemangiomas of the articular synovia, so far as described in the literature, were always located in the knee and presented themselves as more or less circumscribed tumors, often of great extent and often infiltrating the epiphyses. Some of these hemangiomas have been described under the name of arthritis villosa, and are considered to be of traumatic origin. The author believes that the diagnosis of hemangioma of the articular synovia is possible in cases where the tumor is well circumscribed. Often the skin covering the joint has a darker color, and small varicosities will be seen superficially. The tumor has a soft consistency, is sometimes fluctuating and easily compressible. The joint not infrequently

is filled with hemorrhagic fluid when fluctuation is present. Atrophy of the muscle masses of the same side is very marked.

From a differential diagnostic point of view there are to be considered: lipoma arborescens, tuberculosis, syphilis of the joint, and free joint bodies.

The author believes that the prognosis of the angioma itself is benign, and that complete resection of the tumor is the treatment of choice and leads to permanent cure. In those cases in which there is more or less destruction of the joint bodies, resection of the joint is necessary. If such resection is not complete, recurrences are not uncommon.—*A. Steindler, M.D., Iowa City, Iowa.*

Del Trattamento nelle Fratture del Collo del Piede a Grand Spastamento (Treatment of Fractures of the Ankle with Gross Displacement). P. Buonsanti. *Chir. d. Org. di Movimento*, XIV, 375, 1929.

The author presents a clinical and radiographic study, with report of six cases representing Dupuytren's fracture with posterior dislocation of the astragalus and fracture of the posterior lip of the tibia; bimalleolar fractures in abduction of the type of Tilleaux; bimalleolar fractures with valgus deformity. His conclusions are: among the fractures of the ankle, the most complete and also the most rare are those of the type of Dupuytren's with subluxation club-foot of the astragalus. In this type of fracture the initial mechanism is the backward thrust of the astragalus which carries with it, always, the posterior lip of the tibia and is followed by tear fracture of the internal malleolus and impingement fracture of the external malleolus. The diastasis between tibia and fibula, often seen in this type of fracture, is incomplete, involving only the anterior tibiofibular ligament.

The bloodless treatment lends itself most effectively to good reduction and retention of fragments with gross displacement, either posterior or external, and the functional result obtained thereby is such as to make this procedure the one of choice.

The operative intervention is always the exception, but it may become necessary, not so much for good reposition of the fragment of the posterior tibial ledge as for the great diastasis between tibia and fibula for which retention cannot be well obtained with simple plaster-of-Paris bandage. The method of choice in this case seems to be the refreshing of the internal malleolus after Leclerc.

A special type of diastasis occurs in the Tilleaux type of fracture with pathological varus position, where the fragments of the tibia are separated between themselves. Here, the bloodless reduction would not prove sufficient, in order to reconstruct the contours of the tibia, and therefore the necessity arises of refreshing the internal malleolus by open operation.—*A. Steindler, M.D., Iowa City, Iowa.*

Lussazione Traumatica Irriducibile del Ginocchio (Irreducible Traumatic Dislocation of the Knee). C. Benelli. *Chir. d. Org. di Movimento*, XIV, 436, 1930.

The article includes a review of the literature, with the publication of one case. A man of seventy-four sustained the injury by being thrown off a cart to the floor while caught in the lumber with which the cart was loaded. The reduction was carried out by operation through Textor incision; the articulation was laid open. Reduction by manipulation without entering the joint was tried next but failed. Then the joint was opened widely. Patellar ligament, lateral ligaments, and crucial ligaments were completely lacerated. Only after a large muscle flap from the vastus internus, which had become dislodged and blocked the intercondyloid fossa, was removed, was it possible to reduce the dislocated tibia. However, a few days after operation a necrotic process started in the skin wound, gradually gaining in extent and depth, so that amputation finally became necessary.

The author finds ten cases of this type, including his own, described in the literature. Pathognomonic for this irreducible type of dislocation were the interposition of fibrous or muscular masses resisting reduction, and the fact that the patella is fixed in the vicious position and there is a depression in the skin below the femoral condyles. The patella

is displaced outward over the external condyle of the femur The depression of the skin is not seen when the leg is held in abduction, as natural in this type of dislocation, but is brought out when the leg is forced into the normal position to the thigh. Treatment is entirely surgical. Different observers have used various methods of open reduction. Arthrotomy seems always necessary. It is useless to try to suture the torn crucial ligaments.—*A. Steindler, M.D., Iowa City, Iowa.*

CONTRIBUTO ALLA CONOSCENZA DELLA DISTROFIA METAEPIFISARIA CALCANEARE GIOVANILE (CONTRIBUTION TO THE EPIPHYSEAL DYSTROPHY OF THE OS CALCIS). L. Durante. *Chir. d. Org. di Movimento*, XIV, 491, 1930.

The author has been able to collect from the literature only fifty-four cases, contrasting with the enormous statistics of epiphyseal dystrophies in other bones. He reports one case of his own. In the juvenile age, when the epiphyseal bone nuclei begin to appear, epiphyseal dystrophies of the os calcis may be observed. These manifest themselves by swelling over the insertion of the tendo Achillis, extending over the sides of the bone and easily distinguishable from inflammation of the bursa retroachillea and tendosynovitis. The pain is spontaneous, more pronounced on pressure, with slight functional disturbances. In the course of six months to one year spontaneous cure results. The author describes the microscopic findings in his case, which were characterized by rich vascularization of the periosteum. There were no bacterial findings nor any cell formations indicating an inflammatory process.

The author considers the condition in the light of a growth dystrophy with subchondral aseptic necrosis in the spongeous tissue. The radiographic findings show the same fragmentation of the epiphysis as seen in other types of growth dystrophy.—*A. Steindler, M.D., Iowa City, Iowa.*

CARCINOSI OSTEOPLASTICA DIFFUSA DELLO SCHELETRO DA CARCINOMA PRIMITIVO DELLA PROSTATA CLINICAMENTE IGNOTO (DIFFUSE OSTEOPLASTIC CARCINOMATOSIS OF THE SKELETON FROM PRIMARY CARCINOMA OF THE PROSTATE, NOT CLINICALLY DIAGNOSED). V. Putti and G. Faldini. *Chir. d. Org. di Movimento*, XIV, 505, 1930.

The case reported is of interest, as it demonstrates that diffuse skeletal metastases may follow a primary carcinoma which remains unrecognized.

The case reported by the authors, which was studied very completely, clinically as well as pathologically, was that of a man of fifty-eight, who was suddenly taken with blow-like pain in the lower extremities. The pain was continuous and not influenced by bed rest. There was considerable loss of weight. The rectal examination of the prostate was negative. The lumbar spine was flattened and the erector spinae masses strongly contracted. Wassermann was negative. The x-ray examination showed that practically the entire skeleton was involved. The density of the bones was greatly increased, with the exception of the bones of the hands and feet which showed a state of decalcification. The bones involved showed condensation in nodes extended over diaphyses as well as epiphyses. The most striking changes were found in the vertebrae, the innominate bones, and the femora.

The clinical diagnosis was diffuse carcinomatosis of the skeleton following a not localizable primary tumor, presumably of the prostate.

The autopsy revealed the prostate greatly increased in consistency, not in size, the middle lobe gone, the gland of whitish color. On section, small nodules of yellowish color, differentiated from the whitish parenchyma, could be made out. The long bones were very much thickened and studded with numerous nodes; the bone was very hard and the consistency increased from the periphery toward the center. The short bones, especially the vertebrae, were of abnormal compactness and likewise showed the node formations at the ventral surface. The pathologic diagnosis was primary carcinoma of the prostate with subpleural nodes; nodes of the left suprarenal gland, invasion of the lymphoglandular system, subdural nodes, and diffuse osteoplastic carcinomatosis of the skeleton. The prostate was found in a state of complete neoplastic degeneration.—*A. Steindler, M.D., Iowa City, Iowa.*

ARTROPLASTICA CON LEMBI APONEVROTICI FISSATI (ARTHROPLASTY WITH IMPREGNATED APONEUROTIC FLAPS). EXPERIMENTAL STUDIES ON RABBITS. M. Dainelli. *Chir. d. Org. di. Movimento*, XIV, 555, 1930.

The object of the author's experiments was to follow the evolution of the interposed flap and the histologic changes it undergoes after implantation. After washing it shortly in running water, the flap was put in ten per cent. formalin for five or six days and then preserved in sixty per cent. alcohol. Before use the flap was put for at least one hour in physiological salt or in Ringer-Locke's solution. The interposed flap acts only mechanically, preventing fusion between the joint bodies. The fixed flap becomes entirely absorbed in from thirty to forty days, but not until the articular bodies are covered with fibrous tissue to a degree to impede securely a reankylosis between these bodies. The regeneration of the articular heads takes on the form of cartilaginous metaplasia, so that in due time an almost normal range of motion is developed.

According to the author, the use of formalin-impregnated fascia offers the following advantages: the possibility of having always suitable sterilized material ready for use; and the avoidance of the additional work incident to the removal of a flap.

The literature is extensively quoted, but no personal clinical experience is cited by the author.—*A. Steindler, M.D., Iowa City, Iowa.*

GENESI DEI CORPI MOBILI ARTICOLARI DI ORIGINE SINOIRALE (FREE ARTICULAR BODIES OF SYNOVIAL ORIGIN). O. Bartoli. *Chir. d. Org. di Movimento*, XIV, 594, 1930.

The author reports a case of a man aged forty-eight, who received a violent blow against the knee. The injury was followed by swelling and disability. On examination a hard elastic body was found, which appeared on flexion-extension movements at the median portion of the articulation. This body was formed by collagen fibers containing numerous fibrocytic elements. The observation is of interest because of the histologic character of the free body.—*A. Steindler, M.D., Iowa City, Iowa.*

ÜBER KNOCHENVERÄNDERUNGEN INFOLGE BEHANDLUNG MIT HERRMANNSDORFERSCHER KOST (CONCERNING BONE CHANGES AFTER TREATMENT WITH THE HEMANNSDORFER RÉGIME). Birk. *Deutsche Med. Wchnschr.*, LV, 1886, 1929.

The author has observed calcification of the rib cartilages and increased calcification of the metaphyseal regions of the knee joints in tuberculous children kept on the Hemannsdorfer diet. This diet is rich in vitamin D. The author agrees with v. Bergmann that the effect of ergosterol is the most important feature of tuberculous diets.—*J. E. Milgram, M.D., Iowa City, Iowa.*

PHYSICAL EQUIPMENT OF THERAPEUTIC POOLS. Charles LeRoy Lowman. *J. Am. Med. Assn.*, XCIV, 845, March 22, 1930.

Therapeutic pools are of value in the treatment of flaccid paralysis, spastic paralysis, joint and postoperative conditions such as in tendon transplants, etc. The value of this form of treatment lies in greater ease of movement of the parts under water, and a maximum degree of cooperation is obtainable.

A pool of convenient size is twelve to fifteen feet wide by twenty to twenty-five feet long. Instructors get best control of patients by working in the pool rather than leaning over the edge. Cleanliness of the water is essential. A low bacterial count may be obtained by the daily injection into the water of hypochlorite solutions. All submerged metal equipment should be bronze, chrome nickel, or enamel, to prevent rusting. A motor or hand-drawn elevator to carry helpless and heavy patients from the dressing room to the pool is very convenient.

The benefits derived from this form of treatment depend necessarily on the surgeon, the technician, and the equipment.—*P. M. Girard, M.D., Dallas, Tex.*

PREVENTION OF DEFORMITIES IN CHRONIC ARTHRITIS. II. THE SPINE AND THE HEAD. Loring T. Swaim and John C. Kuhns. *J. Am. Med. Assn.*, XCIV, 1123, April 12, 1930.

Deformities following arthritis in the dorsal vertebrae are of especial consequence, because the anterior bowing with rigidity restricts chest expansion and action of the diaphragm. The secondary effect of the forward position is ptosis of abdominal viscera, with its train of symptoms.

Early diagnosis permits preventive measures, which are easily applied, even though the infective process may not be stopped. The patient should be put to bed, with gradually increased extension until the spine is in a favorable position for ankylosis. When muscle spasm has ceased and there is some expectation for regaining motion, exercises are started in recumbent position and continued after getting up for the purpose of mobilization of the spine and increasing muscle power.

Torticollis from cervical involvement is treated by postural measures, to prevent deformity or to correct it if feasible.

III. THE LOWER EXTREMITY. *J. Am. Med. Assn.*, XCIV, 1743, May 31, 1930.

Principles which govern the treatment of deformities in the upper extremities and spine are applicable to the lower extremities. During active infection the joints must be protected by relief from weight-bearing, and supported in splints to prevent deformity. There is the tendency to flexion at the hip and knee; positions in feet influenced by posture are usually equinus and valgus. When deformity has occurred, corrective measures should not be instituted until the active process has subsided. If ankylosis is inevitable, the joint should be put into favorable position if possible.

Reconstructive measures may be employed later with improved function at the joints of the lower extremity.—*W. B. Carrell, M.D., Dallas, Texas.*

THE BONE-GRAFT OPERATION FOR TUBERCULOSIS OF THE SPINE. TWENTY YEARS' EXPERIENCE. Fred H. Albee. *J. Am. Med. Assn.*, XCIV, 1467, May 10, 1930.

All conservative methods of treatment which aim at fusion and cure of a tuberculous joint have their handicaps. Therefore, in 1909 Dr. Albee first began fusing spines for the cure of this disease. He observed the comparative lack of osteogenic power in the bone of the spinous processes, and decided to insert other bone (from the tibia) which had greater osteogenic power.

The Hibbs operation does not furnish the added bone of higher osteogenic power, requires more time, and consequently increases risk and shock. It does not afford a bridge of cancellous bone for increased circulation between the adjacent healthy vertebrae and also to the diseased members.

Indications: Operation is done on any patient at any age, provided the surgical risk is good. Paraplegia, perivertebral abscess, and psoas abscess provide additional indications for operation. High temperature and secondary pyogenic infection are contra-indications. The presence of sinuses is not a contra-indication because usually these sinuses are located away from the spinous processes. When present and near the field, they are sealed off with collodion and cotton. The encountering of cold abscesses does not seem to affect the fusion of the graft.

Technique: This is described fully. Two methods are used,—the large single graft where there is not much kyphosis and the "bundle of reeds" where there is kyphosis. The spinous processes are split with an osteotome, care being taken to fracture but one side. This provides a line of upright spines on one side with the split halves on the other, forming a bed for the graft. In the lumbar region, one vertebra above the disease and one below is included; in the thoracic region, two vertebrae above and two below are included.

Patients are kept recumbent for about six weeks and in young children a Taylor brace is applied for six months. In adults in whom a strong single graft is used, recumbency for six weeks and no brace or any means of support is used. Patients having

paraplegia are kept recumbent until the condition clears up. The general treatment of a tuberculous patient should be carried out simultaneously.

Results are reported in 865 cases,—ninety per cent. excellent or good.—*P. M. Girard, M.D., Dallas, Texas.*

Reduction of Fractures and Dislocations of the Long Bones. An Apparatus for Obtaining General Relaxation of the Soft Parts. Robert Soutter. *J. Am. Med. Assn.*, XCIV, 1547, May 17, 1930.

Traction and countertraction are essential to reduction of fractures. This is best obtained by the use of an apparatus equipped with double block pulleys. This gives an intermittent slow traction to any degree desired.

The apparatus described is a jointed steel tube so that it will fit any part and can be taken apart and carried in a small package. Each end is bent at a right angle,—on one end of this angle is a hook for the pulley, on the other end a ring through which the muslin bandage is tied for countertraction. The second pulley is tied to the Delbet knot which is fastened around the ankle or wrist. Between the second pulley and foot is placed a spring balance by which the amount of traction is gauged.

In the average adult case, under anaesthesia, Dr. Soutter uses ten pounds increasing to fifteen pounds in three minutes, and at three minute intervals to twenty or twenty-five pounds, the maximum pull being maintained for fifteen to thirty minutes. The maximum pull varies with the patient and also with the part involved. This form of traction may be used in an open operation by using sterile muslin bandage for the Delbet knot.

This method affords all the traction needed in any case; also, the method of rhythmically increasing traction produces a relaxed condition of the muscles which lasts from five to seven minutes. The reduction of a fracture under this type of traction is accomplished with a minimum of trauma and very little force.—*P. M. Girard, M.D., Dallas, Texas.*

Köhler's Disease (Osteochondritis of Metatarsophalangeal Joints). A. Dawidov. *J. sovremennoi Chir.*, IV, 1305, 1929.

The author presents a detailed review of the literature, giving the etiology and pathologic anatomy of the condition. He discusses the etiologic factors in his twenty-three cases and concludes that in most of them tight shoes, high heels, and overweight of the forefoot are active factors in the causation of this defect. He is unable to determine a uniform causative agent.

In reference to the treatment, the author adheres to the conservative methods: In early cases, relief of weight-bearing on the affected part of the foot; in advanced conditions, resection, as advocated by many surgeons, may lead to the formation of hallux valgus, and therefore should be performed only in well selected instances.—*A. Gottlieb, M.D., Los Angeles, Calif.*

Preiser-Kienbock's Disease. M. Ssantozki and S. Kopelman. *J. sovremennoi Chir.*, IV, 1361, 1929.

The authors discuss fully the etiology and pathology as advanced by various writers, and present in detail, including pathologic sections of the extirpated bone, one additional case. They come to the conclusion that this disease is not a malacia but an aseptic necrosis of bone, as explained by Axhausen in various publications; that the etiology is, in most instances, an occupational mechanical overexertion and trauma. Early operative interference is indicated.—*A. Gottlieb, M.D., Los Angeles, Calif.*

The Influence of Blood Transfusion on the Activity of the Bone Marrow. B. Bogdanov, O. Balajeva, I. Malanz. *J. sovremennoi Chir.*, IV, 1612, 1929.

Although the beneficial influence of blood transfusion on the general condition of the patient is known, the theoretical foundation and its action are far from explained. The

transfused blood serves partly as a substitute for the blood of the patient, partly to activate various organs, among which are the bone marrow and the entire blood-forming apparatus.

To study the influence of the transfused blood and the function of the bone marrow, the authors utilized the supravital stain of the erythrocytes, which permits the determination of reticulocytes in the peripheral blood. These reticulocytes point to an augmented activity of the bone marrow. Their observations allow the authors to arrive at the following conclusions:

1. The reticulocytes indicate a heightened activity of the bone marrow; the determination of their number is a simple and convenient method of establishing the influence of the transfused blood upon the blood of the recipient, and the reaction of the bone marrow.

2. The growth of the number of reticulocytes commences, as a rule, in three to five days after the transfusion, increases in the following three to four days still more, and starts then, gradually, to fall.

3. An apparently grave general condition of the patient does not necessarily speak for a complete inactivity of the bone marrow; the function of the latter may take place independently of the existing pathologic process.

4. To determine the reticulocytes, it suffices to take blood samples before the transfusion, four days after it, and on the eighth or ninth day. This will demonstrate the gradual and maximum increase of the reticulocytes.

5. Operations markedly decrease the activity of the bone marrow; blood transfusions, on the contrary, have a stimulating influence upon it. A simultaneous action of both factors lessens the specific action of each.

6. The simultaneous performance of an operation and transfusion is not favorable, because the operative interference lowers the effect of the transfusion.—*A. Gottlieb, M.D., Los Angeles, Calif.*

INTERNAL SPLINTING FOR FRACTURES. R. E. Pascal. *Lancet*, CCXVIII, I, 22, 1930.

Robineau and Contremoulins have established certain biological laws which may be summarized as follows: Osteoporotic changes do not occur after splinting with beef bone or non-oxidizable metal when:

(1) The splints have been mounted and fixed in strict accordance with the laws that a first-class mechanic would apply in setting up a delicate piece of mechanism;

(2) The splints have been calculated to stand the strain to which they will be submitted;

(3) The splint and the pieces of bone which it unites are not submitted to premature mobilization or any disturbance which might compromise the good position originally obtained.

Devices used. Strips and plates are discarded because from a mechanical point of view they do not offer sufficient resistance. Sheaths are constructed to enclose the broken bone completely and grasp it tightly. The length of the sheath depends on the size of the bone, the direction of the fracture, and the number of the fragments. Correct adjustment is easy, for the sheath only needs fitting and tightening. No other immobilization apparatus is required, even for a fractured femur. The joints may be moved a few days after operation, and bony union is secured earlier than after bloodless operation or other surgical techniques.

The long metallic sheaths used for fractures had proved that the Durville bronze used was quite well borne by the tissues. Only three times during eight years had it been necessary to remove the sheath, and healing had been obtained without disturbing it in infected suppurating fractures. It was therefore thought that the bones might be safely enclosed in even more massive material. After subtrochanteric osteotomy of the femur, two independent pieces of metal are screwed into the two fragments, the screws are split longitudinally, and the points separate in the medullary cavity, thus acquiring a very strong hold. The two pieces of metal are then joined by a gear-toothed articula-

tion, which allows the surgeon to correct any faulty alignment and put the limb into the correct position before the device is locked. A bone graft is added to the metal splint to insure bony union. The patient can leave his bed six to eight weeks after operation without ever having been in an immobilizing apparatus. There is no fear of secondary deviation or a return of the original deformity.

Finally, Contremoulins and Robineau have solved the problem of treating cases in which there has been considerable loss of substance. The lower third of the humerus was replaced by a mechanical device made of steel covered with dentist's rubber. Success depended on secure union between the prosthetic device and the bone. After two years there was a slight condensation of the humerus around the metal. A radiogram (shown in text) taken five years later shows the substitute in position. The patient has full use of his arm, works as an errand man with a bicycle, and plays the banjo. Each case requires elaborate investigation, x-ray measurement of bone, special design of pieces for particular duties, a peculiarly thorough sterilization, and rigorous asepsis.

Results. The sheaths for repairing shaft fractures have given excellent results since 1921. In only three out of over 100 cases have they had to be removed. Many of the patients had compound fractures, but this did not prevent consolidation. The sheaths are well tolerated; there was no case of pseudarthrosis. The callus grows inside and outside the sleeve. The big internal splinting devices have never had to be removed, though it is now more than five years since the first case was treated in this way.—*A. Gibson, M.D., Winnipeg, Canada.*

A Belt for the Attachment of Artificial Limbs. E. Muirhead Little. *Lancet*, CCXVIII, I, 86, 1930.

The method of attachment of the prosthesis to the patient's stump has always been a difficulty in thigh amputations. The shorter the stump, the greater the difficulty. Suspenders allow play or "lost motion" in the sitting position.

A belt introduced about a year ago has given good results. This attachment consists of a waist belt furnished with a pair of straps, one of which is secured to the belt in front and the other to the rear of the belt, thence passing diagonally and crossing each other over the hip joint, and finally passing around the thigh socket and being there effectually secured to the inner side of the socket. These straps are adjustable for length, and at the point of intersection at the hip are arranged to pass freely through a guide. Further, where necessary an additional strap is attached to the waist belt at the outer side and carried straight down through the guide to the top of the socket of the artificial limb. This arrangement obviates the necessity for any strap to pass directly downwards at the back of the wearer, securing much greater comfort in sitting. In addition to these advantages, its low cost is an important feature. This belt is peculiarly acceptable to female patients, who find the use of suspenders very awkward.—*A. Gibson, M.D., Winnipeg, Canada.*

Disability Following Certain Fractures. A. J. Cokkinis. *Lancet*, CCXVIII, I, 402, 1930.

1. *Fractures of the Shoulder.*

Adhesions are exceedingly common, especially around the lower and front part of the joint; they may be intra-articular or extra-articular. Early mobilization, heat, massage, active and passive movement will minimize these. Manipulation under anaesthesia is recommended after ten to twelve weeks.

Osteo-arthritis is common in the middle-aged and elderly. Excision of the head of the humerus may be called for. "The results of this operation are usually satisfactory."(!)

2. *Fractures of the Elbow.*

Disability is usually caused by:

(a). *Stiffness of the elbow*, due to adhesions or excess callus. Early mobilization seems to promote stiffness. Prolonged immobilization is much better.

(b). *Ischaemic contraction* need never occur if reasonable precautions are taken when established. Gradual splinting is of value.

(c). *Myositis ossificans.* True bone is formed, usually in the brachialis.

(d). *Injuries to the ulnar nerve.* Usually the injury to the nerve is coincident with the fracture and is overlooked. All cases of fracture should be examined for nerve injury.

3. *Fractures of the Ankle.*

Bad results are so common that many practitioners feel that some degree of disability is inevitable. Nearly all can be traced to one of three complications: gross malunion; traumatic flat-foot; osteo-arthritis. All three can be prevented.

To prevent malunion, it is necessary to secure absolute reduction of every element of displacement at the first. The crucial part of the treatment lies in fixation of the limb in a retentive apparatus. Best is a three-piece sectional plaster case.

Traumatic flat-foot is caused mainly by premature and unguarded weight-bearing.

Osteo-arthritis can be attributed to incomplete reduction. The joint line is broken, and rough ends project into and irritate the joint.—*A. Gibson, M.D., Winnipeg, Canada.*

Résultat Éloigné d'Enchevillement Osseux Transarticulaire de la Hanche dans la Coxalgie (Late results after Transarticular Bone Grafting of the Hip in Coxalgia). Santy and Berard. *Lyon Chir.*, XXVI, 764, 1929.

The authors present the x-rays and the operative end results in patients operated on in 1923 by the method of osseous transarticular graft of the fibula in cases of tuberculosis of the hip. Favorable results were obtained by this method, and the authors point out that the production of a bone graft will lead to complete osseous ankylosis. The juxta-articular arthrodesis also seems to insure complete ankylosis of the hip in coxalgia, but it does not represent the only method of stiffening a tuberculous hip.

The operation consisted of the preparation of a graft thirteen centimeters long, recovered from the crest of the right tibia, in the dissection of the trochanter, and the preparation of an osseous canal after the Albee technique through the trochanter, the neck, and into the acetabulum. The graft was then hammered through the canal into place.—*A. Steindler, M.D., Iowa City, Iowa.*

Perforation of the Acetabulum in Tuberculous Coxitis. Prof. S. Tregubow. *Orthopedia i Travmatologia*, III, 17, 1929.

The author has made his observations mostly among children, and found that in most of the cases the head of the femur was destroyed to a great extent, presenting a conical deformity. In a series of 500 cases of tuberculosis of the hip joint, twelve were found with perforation of the acetabulum showing clearly on x-ray examination. In two cases a central luxation of the head was present. Heavy traction applied with the purpose of overcoming contractures may be responsible for the penetration of a conical head through the acetabulum. Abscesses in the iliac fossa are not common, this being apparently due to frequent closure of the perforated acetabulum. It was always found that a penetrated head is partially or fully destroyed.

Very cautious treatment is recommended, immobilization with subsequent osteotomy being the best.—*Emanuel Kaplan, M.D., New York, N. Y.*

The Neck of the Femur Coxitis. A. Petrowa. *Orthopedia i Travmatologia*, III, 139, 1929.

A group involving only the neck of the femur is isolated among the chronic afflictions of the hip joint. The author comes to the conclusion that whenever there is an isolated focus in the proximal portion of the neck of the femur, it is due to osteomyelitis and not to tuberculosis. Those infections of the neck of the femur are called by the author "metaphyseal coxitis", or "metaphyseal osteomyelitis". The blood shows a moderate

neutrophile leucocytosis, the pus whenever obtained reveals the presence of a gram positive diplococcus. In the ordinary case the process is much shorter than in tuberculosis of the joint. The x-ray shows in old cases a dense calcification of the distal portion of the neck which can help to differentiate this condition from the atrophy and rarefaction of tuberculosis. Foci in other bones are often present. The diagnosis of this coxitis may present difficulties in a secondary tuberculous infection of the hip joint.—*Emanuel Kaplan, M.D., New York, N. Y.*

Treatment of Wounds of the Tendons of the Hands and Fingers. J. Ch. Bloch and Bonnet. *Presse Méd.*, No. 85, 1379, Oct. 23, 1929.

This communication consisted of three parts:

1. A study of the processes of cicatrization of the cut tendons and the biologic conditions which accompany them, insisting upon the very important rôle of the sheath of the tendon and synovial sheaths, and also demonstrating the evolution of both the dead and the living grafts. The experiments with dead and living grafts were to supply the deficiency in the tendon.

2. The second part considered the clinical development of the tendon cicatrices, and the results of the different methods which are described.

3. The third part considered the results which have been obtained.

The important point in this report is the discussion on the subject of both the dead and the living graft. The authors conclude that the dead graft is the superior.

The very important question of the section of the flexor tendons of the hand occupies the larger portion of the report. The authors advocate the procedure of Sterling Bunnell, and insist very forcibly on the care of operative technique.—*Jacques Calvé, M.D., Berck-Plage, France.*

Quelques Données Biologiques et Expérimentales Relatives a l' Ostéosynthèse par l'Appareillage du Professeur Cunéo (Biological and Experimental Findings Relative to Osteosynthesis with the Instrument of Cunéo). R. Frantz and M. Mayer. *Presse Méd.*, XXXVII, 1616, Dec. 11, 1929.

Experiments were made with the clamp used by Cunéo for nailing and encircling fractures.

The authors believe that the material used is well tolerated provided that the course is strictly aseptic. The periosteum reforms rapidly. The microscopic results show a noticeable osseous reaction even in cases in which there is perfect tolerance of the material. At the site of the periosteum one notices a certain cellular infiltration and, in some cases, new formation of spongious substance. In the compact bone one finds in the surroundings of the material of the clamp signs of resorption more or less marked. Finally, in the medullary cavity one sees constantly a building up of trabecular spongious bone around the hooks of the clamp, which penetrates into the medullary canal.

The same reaction was observed in all cases, although the degree of reaction varied from case to case.

The authors found that every time there was a pronounced bone reaction there had existed a certain mobility of the inserted material. This mobility was either primary, if the clamp was not properly applied, or secondary in case the osteosynthesis of bone alignment was mechanically incomplete.

Another factor brought out is the osseous absorption developing around the metalic material, and it is, therefore, logical to assume that a less voluminous material will cause relatively slight rarefaction. In fact, the authors have observed that the osseous reaction following fixed metallic bands or plaques was much more pronounced than that with the less voluminous instrument of Cunéo.—*A. Steindler, M.D., Iowa City, Iowa.*

Giant-Cell Tumors. B. R. Kirklin and Claude Moore. Proc. Mayo Clinic, IV, No. 49, 347, 1929.

This comprises a study of eighty-eight proven cases of giant-cell tumors. Two types are observed in this series, which differ in their gross pathologic and roentgenologic

appearance. The first variety is a central bone tumor commonly situated at the ends of the long bones, is characterized by even expansion of the bone, not breaking through cortex, and by the lacework of bony reticulations which extend throughout the tumor. This variety of giant-cell tumor should not be confused with enchondroma and bone cyst. The second type is made conspicuous by the absence of reticular bony network, has a "melting ice" appearance, due to homogenous lysis of the central portions with thin shell of cortex remaining. This type must not be confused with primary malignant growth of bone, as the former expands rather than invades bone and there is no deposit.

The author also points out that giant-cell tumors are not necessarily confined to the ends of long bones, but may occur in the shaft; they are not confined to long bones, but may occur in the bones of the face, vertebrae, ribs, and tarsal bones.—*Samuel Benthoon Boon Itt, M. D.*, (Bangkok, Siam) *Iowa City, Iowa.*

Osteogenic Tumor: Growth Injury of Bone and Muscular Atrophy Following Therapeutic Irradiation. Arthur U. Desjardins. *Radiology*, XIV, 296, 1930.

Animal experimentation shows marked interference with bone growth and atrophy of soft structures following intensive irradiation of young animals. Adult bone, however, tolerates relatively large doses of radiation. The younger the animal and the larger the dose, the greater is the injury caused by irradiation. After fracture, deposition of callus is delayed only after very large doses.

The case reported is that of a girl nine years of age, with an osteogenic sarcoma of the upper end of the right humerus. A pathologic fracture had occurred.

Treatment by x-ray was given in March, April, May, and July, 1924. The condition of the arm improved steadily, with increase in density of the bone at site of the tumor, and reduction of the circumference of the arm. The following year showed increased bone density with regression of the tumor and the appearance of slight telangiectasis in the overlying skin.

The following year showed marked inhibition of growth in the irradiated shoulder and upper arm, with recession of the tumor, and increase of the telangiectasis. The following year these conditions were more marked; there was no evidence of malignant activity in the tumor. The child was otherwise healthy, and becoming more and more active. However, the reparative process in the bone was irregular; the bone not regaining normal appearance, the irradiation evidently having destroyed many bone cells.

Examination in June 1929 showed the atrophy persisting, but activity increasing and the child's condition satisfactory in every way.—*Edward N. Reed, M.D., Santa Monica, Calif.*

The Analgesic Effects of Roentgen Rays with Especial Consideration of Bone Metastases of Cancer. J. Borak. *Radiology*, XIV, 328, 1930.

Roentgen rays are not truely analgesic, but give relief from pain by their action on the underlying pathologic process. Hence the relief is more delayed in appearance, but of longer duration than from analgesics. The rays are analgesic only so long, and to the extent that they exert healing effects. At times, however, they relieve by acting not on the cancer itself, but only on the secondary inflammatory infiltrate.

Bone metastases of cancer are much more sensitive to x-rays than most bone sarcomas, and the author has found them the most sensitive of any carcinomas. They can be treated with reasonable certainty of influencing them. The presence of cancer tissue in bone produces no pain *per se:* but only by pressure on the periosteum or nerves supplying it, or upon an adjacent nerve.

The relief of the pain of metastases in bone by irradiation is usually permanent; it must then imply a diminution or elimination of tumor tissue. That this is so can be proved objectively by radiograms, and also anatomically.—*Edward N. Reed, M.D., Santa Monica, Calif.*

HODGKIN'S DISEASE, WITH BONE AND SKELETAL MUSCLE INVOLVEMENT. I. H. Lockwood, E. T. Johnson, and Frederick C. Narr. *Radiology*, XIV, 445, 1930.

The authors report a case of Hodgkin's disease in a boy of fifteen, following an attack of bilateral herpes zoster. The presenting symptom on admission was backache. The course was progressively down hill, with fever, loss of weight, night sweats, and pain. Roentgenograms showed the first four lumbar vertebrae involved, the first being wedge-shaped, the others showing loss of density and of regularity. There was rarefaction of the pelvic bones and of the heads and necks of the femora.

At autopsy, the left iliopsoas muscle was found infiltrated with nodules of firm whitish tissue with small areas of necrosis, such as was found infiltrating the lungs and the liver. The bodies of the lumbar vertebrae and the pelvic bones were soft and cut easily with a knife, the bone being replaced by yellowish-white soft tissue with small areas of yellowish mucoid material.

In conclusion:

Shingles is frequently associated with Hodgkin's disease; there is frequently widespread bone destruction in this condition, its predeliction being for the vertebrae; skeletal muscle is frequently invaded by the same process.

In Symmers' fourteen reported cases, the bone marrow was involved in seven, and skeletal muscle in three.—*E. N. Reed, M.D., Santa Monica, Calif.*

LA DÉSARTICULATION TEMPORAIRE (MÉTHODE DU PR. DELBET) DANS DIVERSES AFFECTIONS DU COU-DE-PIED (TEMPORARY DISARTICULATION IN DIVERSE CONDITIONS OF THE TARSUS, METHOD OF DELBET). E. Mériel. *Rev. de Chir.*, XLVII, 502, 1929.

In 1897, Delbet, abandoning the technique of Ollier, used a transverse incision for the opening of the articulations of the tarsus. The incision is made transversely across the dorsum of the foot, generally at the level of Chopart's joint. After resecting or retracting the extensor tendons and avoiding the dorsalis pedis, he lays the tarsal articulations open at Chopart's line after cutting the interosseous and lateral ligaments along these articulations. This finally allows a total disengagement of the forefoot upon the posterior portion of the foot. No other incision, in fact, exposes so completely the tarsometatarsal and Chopart's articulations. One can now easily expose and resect the diseased portion of the articulation. By further extending the foot plantarward, the flexor tendons of the foot and the flexors on the plantar side can be investigated and dealt with. After the operation, the long extensor tendons are individually united. This author operated on six cases of tuberculosis of the foot and gives a report of this series. The operative results were satisfactory, both immediate and late results of the operations were good. The author recommends the method for inflammatory conditions of the tarsus requiring resection.—*A. Steindler, M.D., Iowa City, Iowa.*

PHYSIOLOGIE PATHOLOGIQUE DU MAL DE POTT (PATHOLOGICAL PHYSIOLOGY OF POTT'S DISEASE). Jacques Calvé and Marcel Galland. *Rev. d'Orthop.*, XVII, 5, 1930.

The authors consider the mechanical factors operative in producing deformity in tuberculosis of the spine.

Conclusions: The physiology of Pott's disease is characterized by total inversion of the anatomic conditions of the spine. This is particularly true of the suppression of the rotatory mechanical elastic function which is usually that of the nucleus polposus. Instead, one sees that a veritable hinge is formed in the posterior column, with movement of a rotatory or gliding type taking place at the level of the articular processes. It is a regular slide-clamp movement. This hinge effect is conditioned now upon the form of the body and of the posterior intervertebral articular processes. This constant physiologic movement explains the absence of interfocal and extrafocal corrections in the dorsal spine, and, on the other hand, it implies the possibilities of these extrafocal and intrafocal corrections in the lumbar spine, where the direction of the wedge effect is the reverse. This shows a very important contrast between Pott's disease in the

lumbar and that in the dorsal spine. In the dorsal spine there is no intrafocus or extrafocus of spontaneous correction, whereas in the lumbar spine there always is. The dorsal focus is composed of small vertebrae and, therefore, there is only insufficient and inadequate contact of the bodies. In addition to this, the dorsal section is constantly kept in mobilization by the respiratory movement. The dorsal spine also possesses a narrower spinal canal and is, for this reason, more prone to produce severe paraplegias by compression of the spinal cord. Also, the line of gravity is anterior to the dorsal spine, which is a factor aggrevating the angulation.

All these points prove the severity of dorsal localization and especially of the localization in the upper dorsal region. Therefore, it is the dorsal forms to which one should devote the greatest care and diligence, whether the treatment be conservative or operative.—*A. Steindler, M.D., Iowa City, Iowa.*

Sésamoide Douloureux. Guérison par l'Extirpation. [Painful Sesamoids (Observation of One Case)]. C. Lepoutre. *Rev. d'Orthop.*, XVI, 234, 1929.

The disease is characterized as follows: (1) by a painful stage of the sesamoid,—the pain is acute and causes considerable functional impairment; (2) the radiographic picture shows the sesamoid of a cloudy, blurred appearance.

History and radiographic findings remind one of the epiphysitis of adolescence. The author has used the term sesamoiditis, although there is no proof of the inflammatory character of the condition.

Extirpation of the involved sesamoid of the great toe produced cure, and the operation was carried out without difficulty.—*A. Steindler, M.D., Iowa City, Iowa.*

Sur les Foyers de Calcifications dans les Périarthrites Scapulo-humérales (Calcification Centers in Peri-arthritis Humeri). E. Stulz and E. Brenkmann. *Rev. d'Orthop.* XVI, 481, 1929.

The authors report a case of peri-arthritis of the humerus in a woman forty-two years of age. The x-ray pictures showed a definite shadow above the upper circumference of the humerus. Minute histological examination was made.

The authors refer to affection of the shoulder characterized by pain and limitation of motion. The presence of an irregular shadow is noted, which is generally described as peri-arthritis scapulohumeralis with calcification. This condition was formerly considered as the calcarious degeneration of the subacromial bursa until, following the observation of Wrede, confirmed by Brickner and others, it was found that the localizations of these calcifications were rather in the peri-articular tendons, especially in the tendon of the supraspinatus muscle. It is known now, thanks to extensive radiological examinations, that this affection consists of calcium concretions, very often symmetrical though not often giving symptoms on both sides, which concretions may become absorbed spontaneously. Furthermore, such deposits may exist with total absence of subjective and functional symptoms, or if those symptoms exist they may disappear completely without changes in the calcareous deposit.

In the histological examination the authors found necrosis of the tendinous tissue, calcification, and granulomas within the tendon. According to the findings of Wrede and Moschowitz, these changes occur as sequelae of ischaemic necrosis of the tendons. They are analogous to calcifications found in the tendo Achillis, or to calcified areas which are often found at the point of insertion of the tendons. But here its particular clinical importance is that it is associated with very vivid symptoms of the shoulder. This is easy to understand, since the shoulder is the region in which a great deal of muscle gliding takes place, so that peri-articular calcification may serve as a source of considerable irritation to the function of the arm.

A radiographic study in cases not operated on shows merely a calcareous deposit which brings about the painful crisis. This is often followed by a state of spontaneous absorption, from which the conclusion may be drawn that the painful symptoms are a sign of a process of repair rather than a factor of irritation. They rather indicate a stage of spontaneous healing.

In the case of the authors', an operation was performed and the calcareous concretions found in the tendon of the supraspinatus muscles were removed. In this case a complete recovery with full range of motion was obtained. Because one cannot count upon the spontaneous absorption of these deposits and because of the long duration of the painful attacks, the authors believe that the operative intervention is the treatment of choice, and that there are no recurrences.—*A. Steindler, M.D., Iowa City, Iowa.*

LE DIAGNOSTIC ENTRE LA PLATYSPONDYLIE CONGÉNITALE ET LE TASSEMENT TRAUMATIQUE DES CORPS VERTÉBRAUX (DIFFERENTIAL DIAGNOSIS BETWEEN CONGENITAL PLATYSPONDYLY AND TRAUMATIC FLATTENING OF THE VERTEBRAL BODIES). Tavernier et Massias. *Rev. d'Orthop.*, XVII, 25, 1930.

Platyspondyly is a term introduced by Putti in 1910, signifying a flattening of the vertebral bodies with enlargement and especially with malformations of the anterior column. There is anterior rachischisis. The authors find that the literature yields only a very limited material of congenital platyspondyly. They were able to find only thirty-eight observations. In the majority of these cases,—that is, in thirty-three out of thirty-eight—the condition became manifest in infancy with other rachitic deformities, with abnormal suppleness of the spine, or as secondary deformities representing merely exaggerations of the normal curves of the spine. Most often the deformity itself is present in the form of a kyphosis, or rarely in the form of a scoliosis. The seat of the lesion is almost always the mid-dorsal or lower dorsal section. Only five cases have been observed which originated apparently in adult age. In twenty-nine out of thirty-eight cases the x-ray picture is definite, since the platyspondyly is accompanied by cleft of the vertebral body. The height of these bodies is less than that of the neighboring vertebrae. The side view is also characteristic. It shows the diminished height of the vertebra. Sometimes it involves one vertebra, more often several vertebrae and occasionally two vertebrae at a distance. Only five cases showed this condition of platyspondyly without cleft of the vertebral bodies.

Of these thirty-eight cases of platyspondyly, none present a definite clinical entity which even faintly gives the picture of a latent fracture. The authors find that there is a distinct difference between traumatic vertebral crush leading to flattening of the vertebra and the congenital type of platyspondyly which is being discussed.

Above all, traumatic flattening of the vertebral bodies is infinitely more frequent than the congenital malformations. In doubtful cases, even in the absence of the clinical history, the radiogram alone allows one to suspect traumatism, as one sees in the x-ray picture cuneiform vertebrae with convergence of the superior and inferior border of the bodies; in congenital platyspondyly the lateral view always shows a parallelism of the upper and lower contours of the vertebral body. Clinically, the principal difference is that the congenital conditions usually manifest themselves in infancy with vertebral deformation which is not painful, which has its location at the mid-dorsal region or lower dorsal region, and is also accompanied by very distinct radiographic evidence. On the other hand, the acquired lesion of the adult is consecutive to a trauma often localized in the dorsolumbar region and giving the already described characteristic x-ray picture, and is radiologically as well as clinically entirely different from the congenital malformation. It is being mentioned that only exceptionally the congenital malformations manifest themselves late,—that is, at the adult age—by symptoms of pain, and only exceptionally that the malformation involves one vertebra only.—*A. Steindler, M.D., Iowa City, Iowa.*

DEUX CAS DE KYSTES ESSENTIELS DE L'HUMÉRUS OPÉRÉS (TWO CASES OF CYST OF THE HUMERUS OPERATED). Oudard. *Rev. d'Orthop.*, XVII, 37, 1930.

The cyst formation of the humerus is called by the author a "kyste essentiel", employing a term used by several French authors.

Two cases are reported: In one case a certain enlargement of the humerus was observed and attention was not paid to the condition until the advent of a fracture; in the second case the cyst involved the shaft of the humerus and it came to the attention of the physician only after spontaneous fracture. There was no pain in either case, nor any oedema. In the first case the cyst had considerable dimensions, occupying almost the entire humerus beginning with the surgical neck. In the second case the cyst was less extensive, and was confined practically to the second fourth of the shaft.

The treatment consisted in operation which was according to the technique of Mouchet,—that is, in evacuation and drying of the cyst and implantation of osteo-periosteal graft.

The second case was seen again eight months after the operation and showed almost complete consolidation of the shaft of the humerus.—*A. Steindler, M.D., Iowa City, Iowa.*

KYSTE DU MÉNISQUE EXTERNE DU GENOU (CYST OF THE EXTERNAL MENISCUS OF THE KNEE). A. Folliasson. *Rev. d'Orthop.*, XVII, 44, 1930.

The author reports a case of pseudo cyst of the external semilunar cartilage. The cyst had a multilocular character. The author refers to the monograph of semilunar cyst by Mouchet,—according to him these cysts are rare, and are almost exclusively found in the external semilunar cartilage. A pathognomonic symptom of the cyst is that it follows the movements of the meniscus and becomes effaced in flexion of the knee and manifest in extension.

In the author's case the cyst was at first considered a synovial one, but upon closer examination the nature of the cyst as being in contrast with the external meniscus was recognized. The degenerative character of the cyst became evident from the histologic examination. It consists principally in a liquifaction within the connective substance of the cyst.

From the viewpoint of treatment the author has, contrary to the technique of most of the authors, refrained from doing a total resection of the meniscus, but has left intact part of the central portion of the semilunar cartilage. There was no recurrence and the functional result was good. The author considers the question of why it is always the external and never the internal meniscus which shows cyst formation. He believes this is the case because the external aspect of the knee shows a greater thickness of the fibrous capsular covering and is also less protected against traumatism.—*A. Steindler, M.D., Iowa City, Iowa.*

LE TRAITEMENT RATIONNEL DU MAL DE POTT EN 1929. Jacques Calvé and Marcel Galland. *Slovanský Sborník Ortopedický*, IV, 341, 1929.

Drs. Calvé and Galland have presented a report of the accepted treatment of tuberculous spondylitis as recognized at the present time. They state definitely that they consider the conservative, recumbent treatment is the treatment of choice; that osteosynthesis is a useful adjunct; and that the ambulatory treatment, either with or without the operative, should be abandoned. The normal anatomy and physiology of the spine in its bearing on this disease is considered, including the part played by the nucleus pulposis. Particular attention is given to these considerations in reference to their bearing on the three regions of the spinal column, and they insist that the application of the therapeutics must be essentially different in the different regions. The plaster bed is extensively used,—its uses and mode of application are stated in detail. The subject of the osteal graft is discussed under the headings of the age of the patient and the location of the disease, including the region of the spine. They consider that the operation should be used with caution in children, and among the reasons given are the greater ease of the invasion of the tuberculous process, and the fact that frequently ankylosis occurs under conservative treatment. The dorsal region is the most desirable site for the operation.

KIENBOCH'S DISEASE: REPORT OF A CASE. Allen F. Voshell. *Southern Med. J.*, XXIII, 321, 1930.

This is a report of a case of the rather rare condition of traumatic osteoporosis of the carpal bones. X-rays show a characteristic thinning and disintegration of bone, most often seen in the semilunar, or scaphoid bones. A brief review of the literature is given. Conservative treatment is usually employed. The author reports a case he operated upon and gives the pathologic findings.—*F. G. Hodgson, M.D., Atlanta, Ga.*

NON-OPERATIVE TREATMENT OF CONGENITAL CLUBFEET: A REVIEW OF ONE HUNDRED CASES. J. H. Kite. *Southern Med. J.*, XXIII, 337, 1930.

No cutting and no manipulations under anaesthetics were used. Most of the patients were infants, but recently older cases were so treated. Ten patients were between five and eight years, three were over nine years old. The technique of applying the plaster casts is given. The treatment is divided as follows: (1) correct the varus deformity, (2) correct the equinus, (3) retention in over-correction, (4) follow-up treatment. Plaster casing is applied over sheet wadding, without undue force, from toes to above flexed knee. Once or twice a week a wedge is cut from the outer side of the foot piece and the forefoot carried further into valgus position. After three wedgings a new cast is applied. About thirty to forty per cent. valgus is obtained before any attempt at correcting equinus is made. Wedging for dorsal flexion is done by cutting the foot piece in the shape of a low quartered shoe and removing a wedge from the front of the ankle joint, and dorsal flexion is repeated until foot comes to ninety degrees or less. The foot is held in extreme dorsal flexion for eight to twelve weeks. Cast is changed every three weeks. Braces are never needed. A swung-out shoe is used. Shoes are worn night and day for six months. Patients should be under observation. Any tendency to relapse is treated by immediately putting the foot back in plaster. A good or excellent result was reported in eighty-five per cent. of the cases. A better functional and anatomical result is obtained by this method than by any other means. —*F. G. Hodgson, M.D., Atlanta, Ga.*

CHONDROSARCOMA OF BONE. D. B. Phemister. *Surg., Gynec. Obstet.*, L, 216, 1930.

In studying sixty-one cases of bone sarcoma the author found ten that he classifies as chondrosarcoma on account of their distinct morphologic, clinical, and roentgenologic characteristics. He wishes to establish this group of tumors as a separate entity, separating them from the general group of osteogenic sarcomata. Generally, large islands of cartilage are seen in which the growing regions may show karyokinetic figures, hyperchromatic nuclei, and other evidences of malignancy. However, in some cases it is difficult to find microscopic evidence of malignancy. The older portions of the tumor often calcify and it is this calcification that throws the characteristic irregular blotchy shadow on the x-ray plate. The tumors grow rapidly and give rise to metastases late.

Ten cases are reported. Of these one is alive ten years after excision, one is alive nine years after amputation and one is alive three and one-half years after amputation. These results suggest a better prognosis for this type of tumor than for osteogenic sarcoma —*F. M. Cowart, M.D., Iowa City, Iowa.*

HEMANGIOMA OF TENDON AND TENDON SHEATH. M. S. Burman and J. E. Milgram *Surg., Gynec., Obstet.*, L, 397, 1930.

Six cases of hemangioma of tendons and tendon sheaths are reported,—two were found in the upper extremity and four in the lower. Radical excision is the treatment of choice, and this treatment was followed in this series with good results in all except one, which recurred. A secondary removal was done, followed by x-ray therapy, and the patient was apparently well one year after the secondary operation. The prognosis for complete cure in this type of tumor is good except in the diffuse infiltrating type, and this type is greatly benefited by removal of the mass. Only one case has been reported in which malignant degeneration occurred.—*E. M. Cowart, M.D., Iowa City, Iowa.*

DIE PROGNOSE DER GELENKSTUBERKULOSE (THE PROGNOSIS OF JOINT TUBERCULOSIS). Edo Deutsch. *Wien. klin. Wchnschr.*, XLII, 1287, 1929.

The author remarks that his clinic has treated 832 cases of bone and joint tuberculosis out of a total of 2768 orthopaedic admissions (37%). He then outlines his opinions without, however, submitting statistics on this group.

In considering statistics he remarks that practically all the old large compilations of results in the treatment of tuberculosis are hardly worth the paper they are written on, inasmuch as without the tuberculin test and the x-ray the accurate diagnosis of tuberculosis is not possible. Thus Sundt, reviewing the x-ray pictures of 243 cases of supposed tuberculosis seen in the Küstenspitale of Frederiksvaern from 1903 to 1918 found but 171 which corresponded to our present concept of tuberculous hips. The remaining cases appeared to be Perthes' disease (41 cases), arthritis deformans (15), osteomyelitis (6), syphilis (2). From 1911 to 1918, there had been 113 cases of supposed tuberculosis. These were reviewed with tuberculin test and x-ray. Of this group he stated only sixty-four were "surely, presumably, or possibly" tuberculosis. The remaining forty-nine cases fall into the different groups outlined above.

The situation with respect to other joints is probably the same.

In general, the prognosis is more favorable in children because the process is more circumscribed. Bone tuberculosis has been more benign than joint disease. Similarly, purely synovial joint lesions are more benign than the purulent tuberculous arthritides. The site of the lesion influences the prognosis. The upper extremities, free of weight-bearing, do much better than the lower. The shoulder may do very well, the weight of the arm relaxing the joint surfaces.

He is opposed to surgery in children and permits it in adults only in the spine (using the Albee fusion).

The conservative method aims at a joint preserving some function. Between the use of an ensheathing cast or a perforated extension appliance there is little difference except for the fact that the latter permits the use of heliotherapy in better fashion. He contrasts König's mortality of forty-three per cent. to forty-six per cent. following resections with Lorenz' and Lange's ten per cent. to eleven per cent. following conservative treatment.

The duration of the lesion varies with the complications and situation of the disease as well as other factors. In general the tabulation would seem to be:

Spondylitis—three to four years.
Hip —three to four years (often more).
Knee —one to two years.
Smaller joints at least one year (without complications).

Cold abscesses if not secondarily infected do not prolong the illness. There is often a residue which will flare up not infrequently after attempts are made to correct deformity by open or even closed operation.—*J. E. Milgram, M.D., Iowa City, Iowa.*

ZUR DIFFERENTIALDIAGNOSE DES MYELOMS (THE DIFFERENTIAL DIAGNOSIS OF MYELOMA). A. Fessler and R. Pohl. *Wien. klin. Wchnschr.*, XLII, 1736, 1929.

That the differential diagnosis is often a matter of great difficulty is illustrated in the case reported. A male aged seventy-four appeared because of a defect in his skull. The x-ray revealed a six centimeter by five centimeter defect with no evidence of repair in the surrounding bone. Wassermann was one plus and luetic reaction positive, but patient denied syphilis and no other suspicious findings were elicited. Repeated x-rays of the entire skeleton revealed nothing but a defect in the clavicle. Two months of antiluetic treatment was followed by the appearance of a negative Wassermann. In the course of a few months the patient rapidly became worse, and died of a bronchopneumonia. At autopsy myeloma was found. Several smaller lesions were found in the calvarium. Others were present in the sternum, the left clavicle, several ribs and several vertebral bodies. The tenth dorsal vertebra was completely replaced by tumor.

Bence-Jones bodies had never been sought in the urine. The positive Wassermann probably was false.

It is unusual to find a single myeloma lesion as large as the one present in the skull.

Two-thirds of the cases reported have been in males of advanced age.—*J. E. Milgram, M.D., Iowa City, Iowa.*

DIE MYOSITIS OSSIFICANS TRAUMATICA UND IHRE BEZIEHUNGEN ZU DEN ELLENBOGENGELENKSVERRENKUNGEN (TRAUMATIC MYOSITIS OSSIFICANS AND ITS RELATION TO DISLOCATION OF THE ELBOW JOINT). A. Blencke. *Ztschr. f. orthop. Chir.*, LII, 189, 1929.

The literature of the subject is painstakingly reviewed and illustrative cases are reported. The shadow of the newly formed tissue is visible in the roentgenogram often two to three weeks after the injury. The author urges in such cases, and as prophylaxis also, rest of the joint and application of heat. Massage and movement should not be permitted, for all reports agree that the bone formation is only increased by such treatment. As far as the genesis of the bone is concerned, the argument as to whether it is the result of periosteal growth or metaplasia, or both, is still in progress. It is not necessary to predicate a dislocation for the appearance of myositis ossificans, as numerous observations show that other joints may be affected.

The author stresses the importance of not adding a reduction trauma to the insult of the original injury. For this reason he urges reduction under deep narcosis with complete muscle relaxation. As to operative intervention, such attempts should be limited to removing masses interfering with joint movement or involving nerves or vessels.

The bibliography appended occupies more than ten pages and is apparently intended to be comprehensive.—*J. E. Milgram, M.D., Iowa City, Iowa.*

ÜBER DIE OPERATION DES KLUMPFUSSES BEIM ERWACHSENEN NEBST STATISTISCHEN BEMERKUNGEN (OPERATIVE TREATMENT OF CLUB-FOOT IN THE ADULT WITH STATISTICAL REMARKS). Alfred Schulz. *Ztschr. f. orthop. Chir.*, LII, 247, 1929.

In four years in a clinic aggregating 3545 admissions, 250 cases (seven per cent.) were admitted for club-foot. The report concerns the twenty-two adults comprising this series. All were severe, for the most part from isolated communities, and for that reason neglected.

Wedge osteotomy of the tarsal bones suggested by Velpeau in 1839 was performed first by Weber of Heidelberg in 1866. When osseous deformity is present, either forcible redressment by Schutze's osteoclast, or open operations come under consideration. The objections to the former in the most marked cases lie in the traumas produced. In the hands of an expert, probably these objections can be diminished. If open operation is to be undertaken, it seems to the author that multiple wedge osteotomies, sparing the joint surfaces, are not desirable, mainly because of the difficulty in obtaining good postoperative alignment.

Of the twenty-two cases, two were amputated because of deep multiple pressure ulcerations. The remaining twenty were operated on through a lateral curved incision of the Kocher type. The base of the wedge removed was lateral, and its apex medial. It was chiselled from the calcaneus, astragalus, and cuboid regions. Occasionally the scaphoid had to be resected, the peroneal tendons reefed, and the Achilles tendon lengthened.

Complications were limited to thrombosis with resultant forefoot gangrene in a sixteen-year-old female patient. Stiffness as a result of the operation was not marked. The foot is not appreciably shortened by operation. One pyogenic wound infection was observed.

As compared with redressment, which requires two or three sittings, correction is obtained in one and the period of treatment is considerably shortened.

Following operation, a well fitting cast is applied and left unsplit whenever possible for four weeks, by which time bony fusion is present. A short-leg Hessing brace is fitted and worn for the next one to one and one-half years.

Observation at four or six month intervals is insisted upon, that residual deformities may not develop. The author reports very satisfactory functional and cosmetic results in this difficult group of patients.—*J. E. Milgram, M.D., Iowa City, Iowa.*

Der Lochgips (The Perforated Plaster Cast). P. Pitzen. *Ztschr. f. orthop. Chir.*, LII, 259, 1929.

Since Stromeyer performed the tenotomy a hundred years ago, attempts have been made to correct foot deformities. However, forcible redressment is practised as the most common method of correction. Yet even in Stromeyer's day, G. Krauss was treating the severest club-foot in adults with appliances which exerted their force over long periods. The efficacy of this principle is attested by moulds, before and after treatment, which are still to be seen in Munich. In the last fifteen years the principle has been utilized sporadically by a number of orthopedists, notably Mommsen and Schede. Recently the author has treated forty cases by the application of subthreshold forces exerted practically continuously.

In practice, in the case of an equinus with soft tissue contraction, he constructs a cast whose sole is quite open, the patient bearing his entire weight upon a bridge left beneath the metatarsal heads. The cast is applied in the position of maximum correction and extends to the junction of the upper and middle thirds of the leg. The limb is so padded and the cast made loose enough over bony prominences that the heel may gradually settle down. A steel *U* is incorporated to act as a heel support in the line of weight-bearing. The cast is spread if it is found to hinder the descent of the heel. The two limbs are equalized in length to insure weight-bearing on the encased member.

In the instance of spastic hemiplegias where knee flexion would encourage the patient to spare the limb, the cast is carried to the groin, with the knee in extension. It is advisable to change the plaster each ten or fourteen days. The correction gained during the day is maintained during the night by fastening a band previously passed over the dorsum of the foot, tightly over the dorsum of the cast.

Illustrations of a satisfactory result in a severe spastic case of a child of five are interesting.

Club-foot offers apparently more difficulties but is quite amenable to correction. The paralytic club-foot, of course, is soonest corrected. The walking cast applied in correction leaves the heel, the scaphoid region, and the region of the bases of the first and second metatarsals free to settle down.

The contracted flat-foot can be corrected if osseous deformity has not yet taken place. The cast is applied in some equinus immediately after diathermy has been used to decrease muscle spasm. The valgus is corrected rather forcibly as a preliminary step.

In general, the author limits the use of these casts to the moderately deformed cases. He stresses the advantages obtained by avoiding forcible methods which must result in extensive scarring of the foot.—*J. E. Milgram, M.D., Iowa City, Iowa.*

Zu dem Aufsatz von Prof. Dr. Pitzen: "Der Lochgips" (In Reference to the "Lochgips" or Perforated Plaster Cast of Prof. Dr. Pitzen). Krukenberg. *Ztschr. f. orthop. Chir.*, LII, 546, 1930.

In a polemic note the author takes issue with the principles upon which Pitzen's "Lochgips" is based. To correct an equinus foot by placing the weight-bearing surface beneath the metatarsal heads is tantamount to simply permitting weight-bearing without shoes. He points out that if the body weight is to be used as a corrective force, the lever arm constituted by the distance between the center of motion of the ankle joint and the point of support should be made as long as possible. For this reason he had advocated for the past twenty years the insertion into the shoe of a metal plate from heel to the end of the toes. In this manner the lever arm is extended from the metatarsal heads to the point of the toes.

The author calls attention to his long use of thick cleats in the mid-tarsal region for the purpose of correcting flat-foot in children.

The principle of the utilization of the patient's weight in correcting genu valgum and genu varum is to be found in *Zentralblatt für Chirurgie*, XXIX, 655, 1902. Another article by the author is to be found in *Zeitschrift fur orthopädische Chirurgie*, XXV, 27, 1910.—*Joseph E. Milgram, M.D., Iowa City, Iowa.*

Die Drehversteifung (Rotation Method of Stiffening Joints). L. Roeren. *Ztschr. f. orthop. Chir.*, LII, 271, 1929.

The author reports an extremely ingenious, simple, and rapid method of obtaining bony ankylosis in the knee and ankle joints. The complete operation can be performed, he states, in four to five minutes. He has used it since 1924 with complete success. Since the method obtains bony fusion but does not permit correction, the desired position of ankylosis must be obtained before operation, if necessary by turn-buckle casts.

In principle, a cylinder of bone is produced with the aid of a special tubular chisel. Half of the cylinder, in the knee, for example, would be formed by the femur and half formed by the tibia. This cylinder is freed at its base and rotated ninety degrees, so that the section of the former joint line comprised in this cylinder is now in the vertical instead of the horizontal position plane.

The cylinder may be removed in the sagittal or frontal planes as desired. If in the sagittal, after the tubular chisel is driven in deeply, the knee is flexed and the chisel is manipulated to fracture free the base of this bony cylinder. The epiphyseal lines should be avoided. One should keep in mind that the femoral metaphysis is broader than the tibial. Hence the chisel should take off more of the femur than the tibia. In the ankle joint more should be taken from the astragalus than from the tibia.

Roentgenograms showing excellent bony ankylosis are appended.

The method seems rational and simple and in selected cases would appear to be well worthy of emulation. The chisels come in three sizes.—*J. E. Milgram, M.D., Iowa City, Iowa.*

Über Gelenkknorpellösung und Gelenkmausbildung im oberen Sprunggelenk (The Liberation of pieces of Joint Cartilage and the Formation of Joint Mice in the Ankle Joint). A. Sidler. *Ztschr. f. orthop. Chir.*, LII, 302, 1929.

The author reviews the literature concerning free bodies in the ankle joint corresponding to those commonly described as osteochondritis dissecans. The influence of trauma cannot be accurately evaluated. Barth and Kappis maintained trauma is the primary cause, while Axhausen and Koenig attributed the incident to a bland embolis.

The author reports the clinical, operative, and histologic aspects of his case. A female of fifteen had experienced pain and observed swelling over the anterior edge of the ankle joint for four years without known injury. Gait was hindered and running not possible. Conservative treatment proved unavailing. Exploratory operation corroborated x-ray findings in that two loose bodies were found, one in a depression in the astragalar neck and one in a lacuna in the anterior edge of the articular cartilage. Removal of these bodies was followed by a cure.

Histologic section of the bodies revealed peripherally viable cartilage cells; more centrally necrotic calcified cartilage was evident. Most centrally dense connective tissue was found. Section of the tissue lining the niche revealed a similar layer of connective tissue which the author interprets as the site of a previous degenerative process which resulted in the liberation of the joint bodies. No photomicrographs are appended.

A bibliography of the German literature is compiled.—*J. E. Milgram, M.D., Iowa City, Iowa.*

Über die akute septische Koxitis des frühen Kindesalters (Säuglingsosteomyelitis des Hüftgelenkes) [Concerning Acute Septic Coxitis of Early Childhood and its Treatment from a Functional-anatomical Viewpoint]. Ernst Gold. *Ztschr. f. orthop. Chir.*, LII, 353, 1929.

Pathologic luxation of the hip joint after osteomyelitis occurs very early, consequent upon the accumulation of pus in the joint cavity. Inasmuch as after dislocation has occurred, reposition is difficult and with the lapse of time is almost impossible, attention should be paid in the acute stage to such measures as will tend to minimize dislocation. By incising posteriorly to obtain dependent drainage, and fixing the hip in a plaster spica in abduction, the best situation will be offered. If dislocation has already occurred it is advisable to try to replace the head in the acetabulum after performing the drainage. Shrinkage of the capsule obtained in this position is likely to favor retention of the head in the socket. As a rule, movement of the joint after healing of suppurative arthritis in infants is referable to accompanying luxation of the head. A tendency to adduction contracture is observed. The typical deformities of the head and acetabulum are attributed not only to actual destruction but adaptation of the joint surfaces to their new mechanical requirements.

Five cases in point are outlined and analyzed. A bibliography in German and French is appended.—*J. E. Milgram, M.D., Iowa City, Iowa.*

Die Vor- und Rückwärtsbeugung der normalen Wirbelsäule (unter besonderer Berücksichtigung der Änderung, die der Bewegungsumfang in einzelnen Wirbelsäulen erleidet) [Forward and Backward Bending of the Normal Vertebral Column]. Ferdinand Heuer. *Ztschr. f. orthop. Chir.*, LII, 374, 1929.

The striking variations in the mobility of the spine when forward bending is measured in normal spines are referable to the bony relationships of the vertebral bodies. Increased or decreased range of forward bending is dictated by a correspondingly lessened or increased height of the anterior portion of the vertebral body.

A study of the mechanics of the vertebral bodies in forward bending indicates that in increased kyphosis the body weight, acting on the anterior edges of the vertebral bodies, gradually causes a compression of this region of the growing vertebrae. Decreased kyphosis similarly rests upon the height of the vertebral body. In primary lordosis, as he terms it, there results, by forward bending, compression of the posterior portion of the body with a reversed type of wedging.

The compression of the vertebral body anteriorly is possible only so long as it does not exceed a certain height. As soon as the vertebra has become so high as to tend to a primary lordosis, the pressure developed on forward bending will be exerted upon the posterior aspect of the body. Consequently, compression of the posterior portion of the body will occur.—*J. E. Milgram, M.D., Iowa City, Iowa.*

Einige Betrachtungen über Verkrümmungen und über Arthritis (Some Considerations of Deformities and Arthritis). J. van Assen. *Ztschr. f. orthop. Chir.*, LII, 388, 1929.

Of 2,000 patients examined, 1,460 had deformities,—527 males and 933 females. An attempt was made to separate the group of presumably rachitic origin, and correlate, if possible, the incidence of arthritis and the presence and location of deformity.

The author's conclusions were that in later life (leaving the pelvis out of consideration) pedes plani are of greatest significance in this connection. Deformities of the knee and back gave pain in some instances in later life. In general, the incidence of static arthritis in rachitic deformities is exaggerated.

There was little difference as far as sex was concerned, except that in women the arthritis symptoms appeared earlier. The appearance of the climacteric seemed to be a factor in this connection.

The necessity for correction of deformities in early years is stressed. Conservative methods are employed for the most part, but twenty-one patients being operated on within the five-year period. In two years of this period, 800 deformities presented themselves. —*J. E. Milgram, M.D., Iowa City, Iowa.*

AZETONURIE UND HYPERGLYKÄMIE NACH ORTHOPÄDISCHEN EINGRIFFEN BEI KINDERN (ACETONURIA AND HYPERGLYCAEMIA AFTER ORTHOPAEDIC OPERATIONS IN CHILDREN). B. Kutzenok and B. Koldajew. *Ztschr. f. orthop. Chir.*, LII, 395, 1929.

Sixty-three children under sixteen years of age were operated upon. Their urine was examined for acetone before and after operation. One (one-sixth per cent.) evidenced acetonuria before operation and sixty (ninety-five per cent.) after operation. Sex played no rôle in its occurrence. The type of anaesthesia used (ether or spinal) made no difference. Of five cases operated on without anaesthesia, four developed acetonuria. A positive test usually appeared soon after operation and disappeared by the third day. In four cases it persisted for a few days. The routine in all cases was normal feeding the day before operation and sweet tea the morning of operation.

The development of hyperglycaemia in non-diabetic children was observed in seventy-five per cent. of the cases. It appeared in a slightly higher percentage of the patients operated on under spinal anaesthesia. It appeared in those operated on without anaesthesia. The maximum rise was observed one day after operation and the level varied from an average of 130 milligrams to a maximum in one case of 385 milligrams. The duration of the operation was apparently no factor.—*J. E. Milgram, M.D., Iowa City, Iowa.*

DIE PERTHESSCHE KRANKHEIT IM LICHTE NEUER STOFFWECHSELUNTERSUCHUNGEN (PERTHES' DISEASE IN THE LIGHT OF NEW METABOLIC STUDIES). Hans Winter. *Ztschr. f. orthop. Chir.*, LII, 592, 1930.

The author reports a series of determinations of blood calcium and blood sugar in four cases. These determinations were made over a period of ten to seventeen months. He finds in four cases a hypocalcaemia. He states that in the cases observed more than ten months, a fall to normal was observed.

The blood sugar was observed to be low, and in general showed a variety of reciprocal relationship to the blood calcium in that it fell when the calcium rose and vice versa.

The author is inclined to the theory that some endocrine influence has altered the metabolism of the minerals of the body, and that the other juvenile malacias are expressions of similar situations. He finds corroboration of his findings of calcium changes in Perthes' in the article of H. A. Durham and T. A. Outland, published in *The Journal of Bone and Joint Surgery*, X, 301, 1928.

The limits of the chartered variation of the serum calcium are:

Case 1: Five and one-half years old, onset one year before observation. Maximum, 12.8; minimum, 5.5.

Case 2: Eight years old, history of pain for six weeks. Maximum, 11.5; minimum, 6.0.

Case 3: Three years old. Maximum, 11.5; minimum, 8.0.

Case 4: Nine years old, onset of symptoms two and one-half years ago. Maximum, 11.2; minimum, 7.6.

Comment: The appended curves of the blood calcium do not specifically record the individual observations. Blood phosphorous was not determined. The variations recorded in the curves are not striking, and appear to lie within normal limits. In view of the common experience of failing to find significant variations in the blood serum and phosphorous in Perthes' disease, corroboration of the above findings on a larger series is desirable.—*Joseph E. Milgram, M.D., Iowa City, Iowa.*

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